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Growing Working Forests for Hawai'i's Future

Proceedings of the Hawai'i Forest Industry Association 2001 Symposium

J. B. Friday, Editor



Eucalyptus deglupta, a favorite plantation species in Hawai'i

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The Hawai'i Forest Industry Association can be contacted at PO Box 10216, Hilo, HI 96720.

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Cover illustration: *Eucalyptus deglupta*. From E. L. Little and R. G. Skolmen, *Common Forest Trees of Hawaii*, USDA Forest Service, Agriculture Handbook No. 679, 1989.

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AGENDA

Hawai'i Forest Industry Association's 2001 Annual Symposium

June 6, 7, and 8, Kaua'i Coconut Beach Resort

Growing Working Forests for Hawaii's Future

Wednesday, June 6

- 8:30 a.m. Registration & Coffee
- 9:30 a.m. Opening Remarks & Introduction of Keynote Speakers
Sally Rice, President, Hawai'i Forest Industry Association
- 9:45 a.m. Keynote Address: Sustainable Forestry from a Landowner's Perspective and the Green Tag Program
Keith Argow, President, National Woodland Owners Association
- 10:30 a.m. Break
- Technical Sessions**
- 10:45 a.m. Selecting Sites for Commercial Forest Operations
Bill Covern, President, Hawaiian Mahogany Co., Inc.
- 11:15 a.m. Selecting Seed and Seedlings for Working Forests
John Edson, Hawai'i Reforestation Company
- 11:45 a.m. Hedging Your Bets: Selecting Tree Species to Deliver a Continuum of Value
Bart Potter, C. Barton Potter Co.
- 12:15 p.m. Lunch at Kaua'i Coconut Beach Resort
Sponsored by the Symposium
- 1:00 p.m. Economic Analysis of Tree Farms
J.B. Friday, University of Hawai'i at Mānoa, CTAHR
- 1:30 p.m. Protecting Trees with Windbreaks
Bob Joy, Plant Materials Center, USDA, Natural Resources Conservation Service, Moloka'i
- 2:00 p.m. Preparing Sites for Tree Farming
Tommy Crabb, Forestry Consultant
- 2:30 p.m. Break
- 3:00 p.m. Planting a Commercial Tree Farm
Mike Robinson, Pāpa'aloa Plantations
- 3:30 p.m. Fertilizing Trees for Optimum Production
Randy Senock, University of Hawai'i at Hilo, CAFNRM
- 4:00 p.m. Stand Management: Thinning and Pruning Trees for Best Production
J.B. Friday, University of Hawai'i at Mānoa, CTAHR

- 4:30 p.m. Trade Show and Poster Exhibition co-sponsored by Garden Island RC&D, Inc.
and Hawai'i Forest Industry Association
(see schedule on following page)
Pupus sponsored by the Symposium/No-host bar

Thursday, June 7

- 8:00 a.m. Panel on Tree Protection
Bob Osgood, Hawaii Agriculture Research Center, Moderator
Tree Diseases
Wayne Nishijima, University of Hawai'i at Mānoa, CTAHR
Tree Insects
Peter Follett, USDA Agricultural Research Service
Forest Weed Control
Joe DeFrank, University of Hawai'i at Mānoa, CTAHR
Animal Pests
Earl Campbell, USDA Animal & Plant Health Inspection Service
- 9:00 a.m. Property Tax Comparison by Island
Bill Eger, Cannon and Eger
- 9:30 a.m. Protecting Tree Farms from Fire
Bryon Stevens, Kaua'i DLNR Division of Forestry and Wildlife
- 10:00 a.m. Break
- 10:30 a.m. Using Forest Plantations to Mitigate Global Warming Through Carbon Sequestration
Lionel Kutner, TREES FOR LIFE Foundation
- 11:00 a.m. Avoiding Tree Species Which May Become Invasive Weeds
Duane Nelson, USDA Forest Service Institute of Pacific Islands Forestry
- 11:30 a.m. Lunch at Kaua'i Coconut Beach Resort
Sponsored by the Symposium
- 1:00 p.m. Keynote Speaker: Information Vital to Cost Effective Forestry
Rick Hamilton, Forestry Extension Leader, North Carolina State University
- 1:30 p.m. Government Incentive Programs for Forestry
Ron Peyton, USDA, Natural Resources Conservation Service, Kaua'i
- 2:00 p.m. Panel on Hardwood Forestry
Peter Simmons, Kamehameha Schools, Moderator
Koa Silviculture: A Realistic Economic Model
Max Hensley
Bamboo
Don Reidel, Bamboo Guild
Wood Quality, What Does It Mean?
Nick Dudley, Hawai'i Agriculture Research Center
- 3:00 p.m. Break

- 3:30 p.m. Research Updates
 University of Hawai'i at Hilo, *Randy Senock*
 University of Hawai'i at Mānoa, *J. B. Friday*
 Hawai'i Agriculture Research Center, *Nick Dudley*
- 4:15 p.m. Symposium Synopsis and Discussion
 J. B. Friday

Immediately following: Small Landowners' Network Forum co-sponsored by Hawai'i Forestry and
Communities Initiative and
Hawai'i Forest Industry Association

The Trade Show and Poster Exhibition will be open until 6:30 p.m.

Friday, June 8

Field Trip to Kaua'i Island Forestry Sites

- 7:00 a.m. Leave Hotel
7:40 a.m. Arrive at Kilohana Hardwood Plantation, Kīlauea, hosts Joyce and Ed Doty, for 1-hour tour
9:15 a.m. Arrive at Kapaka Forest Stewardship Project, Princeville, host Paul Weissman, for 45-minute tour
11:15 a.m. Arrive at Lydgate Park for lunch
12:30 p.m. Arrive at Forestry Demonstration site in Kīpū, host John Edson, for 30-minute tour
1:15 p.m. Arrive at Hawaiian Mahogany Plantation, Kīpū, host Bill Covern, for 45-minute tour
2:15 p.m. Return to Hotel

Tours to other small-scale tree farms can be arranged through John Edson
(call 808-821-8829 to make arrangements ; or
e-mail: jedson@gte.net)

Tradeshow and Poster Exhibition Schedule

Wednesday, June 8

4:30 p.m. to 7:00 p.m.

Thursday, June 9

7:00 a.m. to 8:00 a.m.

10:00 a.m. to 10:30 a.m.

3:00 p.m. to 3:30 p.m.

4:30 p.m. to 6:30 p.m.

Vendors/exhibitors are asked to have a representative present during the above times to answer any questions about their products or exhibits.

Keynote Address: Sustainable Forestry from a Landowner's Perspective and the Green Tag Program

Keith Argow
National Woodland Owners' Association

Aloha and mahalo. I'm here to talk about empowerment. Yours. I have come to learn, as I received this wonderful board, that *koa no ka oi*. Koa is not only a part of your culture, it is a part of your and our future.

I bring you greetings from Washington DC, from someone who loves to live and work there. Our system does work. Do not give up hope. It is the very best political system the world has yet devised. But we can do better, and we must do better, or we will in fact perish from the face of the earth.

Five years ago I had the pleasure of spending three weeks on these glorious isles with my wife as we celebrated our belated 25th anniversary. We traveled most of the roads on three islands and visited a fourth. I've had the opportunity to come back and see what stunning growth you have here in Hawai'i and also a little bit about how you are planning your future, or letting your future plan you. There's a lot to like in Hawai'i, as you all know, and sustainable forestry is absolutely one of your brightest opportunities. Nick Dudley met me at the airport and promptly took me out to the woods where I saw growth that was truly impressive. But I also saw pig tracks, worse than that, I saw big pig tracks, which is not good for forestry. I saw things that really speak well for your future. Then I got on the plane and John Edson picked me up here on Kaua'i and yesterday we wandered around this gorgeous isle and saw three kinds of mahoganies, none of which were a mahogany. That speaks about the diversity and extraordinary opportunities that lie before us.

A state that looks to its future, as Hawai'i must, will look to its strengths. These strengths will facilitate a sustainable future, a whole future, not a plastic one, and

a happy future. On these islands, particularly this garden isle, we call it paradise. Where else can you walk along a headland and look out upon the ocean, from which we sprang to life, until you come to a growing epidemic of McMansions, and your future stops right there on the private property line. A state that separates its people from their water will one day become as impoverished as the people who separate themselves from the forest. Both sustain life, physically and mentally. Mentally and physically we can take action now, today, this morning, this week, to have the future we want for our children and for their children. Whether that future is a penalty or a blessing is really up to what we do in our lifetime, for we are stewards of this planet, this isle, and these waters. Will it be what is done to us or will it be what we do for us? Will it be proactive or reactive? The choice is ours, and clearly I'm hoping for the proactive side.

This morning I'm going to talk about sustainable forestry from a landowner's perspective. I earn my living, as many of you in this room want to and one day will, from truly sustainable forests, careful management, and really wonderful products. I'm proud of what we grow in our woodlands. I'm going to talk about green tag forestry, and sustainable forestry, and forest certification. Finally I'm going to add a third subject, and that involves you. Because it is our future we're talking about. I'm going to leave enough time for a question and answer session, because this is a two way street. I want you to be thinking of some questions, particularly as it pertains to the national scene, which really is a very bright scene. Believe it or not, it was a bright scene in the last administration and it is a bright scene in this administration. The differences that separate us are re-

ally not differences at all. We are in fact working for a future, and for a whole future.

The National Woodland Owners' Association

We're going to talk about the National Woodland Owners' Association (www.woodlandowners.org). We're going to talk about 42,000 landowners just like yourselves, a lot of them wannabes. I understand that in Hawai'i, with your land prices, you're wannabes. Forestry pays, good forestry pays, but it's going to be hard to be much of an acreage landowner in Hawai'i. But look at the value of what you're growing and compare that with the opportunities that sit before you for sustainable stewardship. Private property responsibility ties in with private property rights. The real thing I'm here to do is to empower you to set the stage for your future and to invite you to join with thirty two other state land owner associations, every one of them independent of forest agencies and independent of the forest industry, but working in cooperation. As an independent voice with independent funding, we can speak our own hearts, and we can serve as the third leg of that tremendous partnership of forest industry, the state forestry agencies, the US Forest Service and the other federal forestry agencies, and the affiliated state universities and the Extension Service. Education beats regulation any day of the week. If you're concerned about regulation, just look to California. I hope you will before very long organize either as a sub-affiliate of this group or as an independent group. We'll organize Hawaiian land owners to be a collective independent voice, because you and I working together grow 60% of America's wood supply. Sixty percent: that's more than all forest industries, more than all municipal, state, and national forests combined. We are the source of Americas' *homegrown* wood supply. Now of the *total* wood supply, thirty-some percent comes from Canada, and that's ok. We can grow wood in America and these islands like no one else can because we have wonderful habitats and wonderful sites that God has given us to steward. With our personal stewardship, we can grow timber competitively with anyone.

Top ten forestry issues

These are our top ten forestry issues for 1999. These are the nuts and bolts of how we plan our sustainable future as landowners. We live in an ecological system that we can handle. We know how we can stop the mud from flowing off the land. We know how we can block the wind with windbreak plantings. We know a lot of things

that involve our markets. But we know less about our political future. We're not nearly as good at that as organized labor or the farmers. We have to organize and be more proactive, so that our elected officials can understand from whence we spring and why we ask for what we're asking.

1. Taxes

Fair and stable income, inheritance, and property taxes. We're doing better than we've done in a long, long, time. This year that will be it up for 2001 because we've finally signed a tax bill. The 2001 tax bill does phase down the "death tax", the inheritance tax, which allows us to pass our stewardship on intact, without capitalizing it to pay the taxes when it passes on to the next generation. Property taxes are something you and I have to fight for every year, and that's not done in Congress, that's not done at the state. That's done at the local level, although we can empower how that is done at the state level through land-use taxation. I understand that you have just done that here in Hawai'i, and you have succeeded, and my congratulations to you, particularly here on Kaua'i.

2. Right to practice forestry

The right to practice forestry surprisingly is our number two issue. Who would ever challenge your right to practice forestry? Seemingly anybody who sees a tree cut, not realizing that this podium is where that tree went, or that paper, or the wonderful woodwork you can see in the museum here. Our right to practice forestry springs from the authority granted by the state legislature to the various counties and municipalities to regulate harvesting. We are perfectly willing to live with reasonable regulation and not degrade the environment. It's always been against the law to harm your neighbor and to harm society. You make a lifetime investment, or in your case a ten year or twenty year investment in forestry, surely you should have the right to capitalize on that investment, just as you have the right to sell your corn, your taro, or whatever it might be.

3. Private property rights

Our third issue is private property rights. We tend to be a paranoid group because we feel property rights are slipping away through our very fingers. I feel sorry if you feel that way, because my property rights are not threatened; they never have been. In the Constitution they're guaranteed in my stewardship of the land. As long as I practice the stewardship my heart tells me to,

and fortunately I have been educated to, my property rights are not threatened. So we tie that with a private responsibility code you'll see a highlight of a little later. We feel that by being proactive we have a much stronger hand than by being reactive. And we can help forestall further legislation that degrades our property rights if we in fact are managing by example.

4. Landowner liability

Landowner liability is a fourth issue. There are reasons why your roads here in Hawai'i are gated at night. These are social reasons in an age that has not caught up with its culture, particularly a culture whose actions are induced by drugs and who knows what. But we will, in time, learn how to deal with a stunningly changing society. We saw the Industrial Revolution. The computer revolution, the information revolution, where everything of quality is somehow trivialized in an x and y code is something we will learn to deal with, and one of the ways we deal with it is that truly wonderful greeting that was called out this morning, in a language that is foreign to me, but certainly sounds comfortable.

5. Forest stewardship and cost-sharing

Forest stewardship and cost-sharing have fallen on hard times. We support the stewardship program, which is primarily state forestry. We could do without government cost-sharing, and some would rather do it that way. I talked to a rather large landowner here in Hawai'i yesterday and he's never accepted a dollar in cost-sharing, and he doesn't intend to. I have. I have signed a stewardship pledge in two states and I'm very comfortable with the assistance I received. Probably, however, we've got to find a better way to guide that money to those people who really need it.

6. Forestry extension education

A very bright spot in our future is forestry extension education. We are flat-out advocates for forestry extension. Education is how you and I empower ourselves: by learning. Our motto for the National Woodland Owners is "Informed woodland owners are our best protection." I can't help you when you've done something dumb after you've done it. But I can teach you what's going to happen to you if you do that which has been proffered to you by Lucky Logger or whoever it is.

7. Professional forestry advice and logger certification

One of the strongest points of the Sustainable Forestry

Initiative is training of loggers. We'll be seeing more of that. Professional forestry advice comes to us from all directions, and if we don't avail ourselves of that it's our own loss.

8. Forestry on wetlands and soil conservation

You know, we still don't know what a wetland is, but it has been subject to regulation. We know wetlands are important to an ecosystem; therefore we are going to deal with them in some way. We've been unable to get anywhere on legislation, so we have just started a national wetland registry, by landowner. We're saying to America, we know we have a wetland. We're defining what we think is wet. It's a proactive move, rather than waiting for someone else to come in and define for us what they think a wetland is.

9. Wildfire

Particularly in the wildland-urban interface, you have some real fire opportunities. We have simply got to understand why wildfire better. As landowners we have been paying for state fire protection that is now going to protect subdivisions, not our land. They backfire our land because it's a wasteland. It's a working forest, but they backfire to protect those new McMansions up on the hill. I think we're nuts to be letting our woodlands burn to protect the mansions that have crawled in among them like a cancer. It's our people doing it; we're selling those lands to developers. There's nothing wrong with that, this is a free enterprise system, but there's something wrong with that if we can sell land anywhere we want to without guidance and without caring about the woodland heritage of our people, nature, and our neighbors.

10. Log exports and free trade

We're a free trade organization. In the Pacific Northwest, they define that as the right to ship anywhere in the world, but keep that Canadian lumber from coming south. Well, it doesn't work that way.

The National Woodlands Owners Association

I hope many of you, before I leave, will present a \$25 check to join the National Woodland Owners Association. For \$25, you get 12 publications a year. Four issues of National Woodlands magazine, and you also get eight issues of Woodland Report, which is a legislative newsletter which not only tells you what is happening with you and for you and to you in Washington, but it also tells what your colleagues in your state affiliates

are doing. Some of our state affiliates are really getting across some neat legislation. I'm particularly proud of Delaware, because if you do a forest management plan in Delaware, they waive your property tax. I also spoke earlier about the private property responsibility initiative. Twenty four of our 32 state affiliates have adopted that initiative. In it, we offer six things, we expect six things. I've talked about the six things we expect; what we're offering is just common sense. You know, the most wonderful definition of forestry I ever heard was Carl Schenk's: the first forester, director of the first forestry school in America, and he succeeded Gifford Pinchot as the manager of the Vanderbilt estate in North Carolina. His definition of forestry was "Common sense applied to woodlands." And that's really what the private property responsibility initiative is all about.

Green Certification

We've just certified the first tract of National Forest land to be certified in the United States. Part of that is the Pisgah National Forest, that estate which was managed by Gifford Pinchot and later by Carl Schenck. That brings us to the National Forestry Association, which is our newest partner in land ownership. The National Forestry Association is an association of forestry advocacy for independent landowners. One of the benefits of National Woodland Owners membership is an introductory visit from a consulting forester at no cost. We urge you to take advantage of that visit, along with a visit from your state service forester.

National Forestry Land Trust

The National Forestry Land Trust is a third party land trust. Land trusts make sense for woodland owners if you want to keep your land in productivity for ever. Many of you are willing to grant a conservation easement. We're a third-level trust. The first level would be a local Kaua'i land trust. The second level would be a state land trust that would step in and help if for any reason the Kaua'i land trust folded. These easements, which are in perpetuity, would pass to a state agency, or to whom-ever you wish. Finally if for some unforeseen reason, the state should suddenly become un-empowered or somehow co-opted, your testate, like a will, would be enforced by the national level, by people from throughout the United States who come in and stand behind you. We don't ever expect to have to do this, but we're there and we're ready to do it.

Fire Lookouts

You have two in Hawai'i, can anybody tell me where they are? One of them is really a volcano lookout. The second one is on O'ahu, in Mākaha, at the military firing range. They blow the devil out of some sacred valley, and they burn it regularly, and they have a fire lookout right there. They have a fire truck down below and they run up and put it out, and then they commence firing again. Forty-nine states have fire lookouts. The only one that did not was Kansas, and we're working with the state forester of Kansas.

Green Tag Forestry and Certification

Green Tag Certification is an independent program that developed after the big four were in place. The oldest certification program is the Tree Farm program of the forest industry. Then came along the Forest Stewardship Council from the environmental community, which set up quite a high level of certification that included indigenous people's rights and a whole variety of issues. FSC certification is an international movement. The forest industry took a look at that and responded very proactively, very positively, with the Sustainable Forestry Initiative. It focuses less on indigenous rights and more on harvesting, especially on keeping harvesting at a positive, sustainable rate. We took a look as independent landowners and we realized that if FSC sweeps the world, Tree Farm wouldn't get us access to that. (Tree Farm does give you access to SFI since they have a reciprocity agreement.) We developed Green Tag to have access to FSC, although we've not yet achieved that level. However, in an independent evaluation by Oregon State University, it turned out that both Green Tag and FSC scored 26 out of 28 evaluation points. We are more intensive in our forestry than FSC is. We are less intensive on Native American rights to our land. Here in Hawai'i that may be a very special calling, and you will have to devise something that works for you here. I think certification does make good sense. It's certainly here, and we're going to deal with it as best we can.

The first element by which we evaluate Green Tag forestry is your forest management plan. Is it thorough and complete? Does it include the understory species, do you know what's there, and do you have a good idea what the endangered species on your habitat are? Are you running from endangered species or are you embracing them? I tell you to embrace them, because you cannot

hide. Don't shoot, shovel, and shut up. That's not the answer. The answer is true reverence and understanding of the sites. Another thing we look at is how we show respect for Native American heritage sites. We work with the native peoples who are related to that site historically, but we do not grant them ownership of it, because we're paying the taxes, we do not grant them unlimited access, unless that's your choice, and we do not make it a public shrine unless that's your choice. We talk about the soil, the water, the whole ecosystem, but we talk more than any one else on how our timber is harvested. Is it harvested in such a way that you do not damage that site for future harvests? We spend a great deal of time on how you get in and out of watercourses, particularly when you have as much water as you have here in Hawai'i. We talk about all those things and we evaluate your plan and your forest management with a professional forester that we send you. The forester is working for you under our guidance; he bills you directly. All of our foresters are members of the Society of American Foresters, their credentials are reviewed by us, and they're either active members of the Association of Consulting Foresters or Forest Stewards Guild, which is another professional forestry society which is a little less oriented to the timber and more oriented to the alternative forest incomes. We have a follow up system every

five years, very much like the rest. When you're done, you have a chain of title with us. Chain of title means that your green logs (because our program has been from seedling to the landing) will have a symbol on them as they go to market. This symbol will first show up on lumber in San Francisco next month with a shipment of lumber custom harvested from a landowner in Oregon.

The environmental community has largely gone on record as stopping all forest harvest on all National Forest lands. Some of what was harvested, as you and I know, on corporate land as well as on our own land, was not harvested sustainably, and therein generated a backlash that has brought us to this terrible conflict that we face today. The environmental community called us "the fox guarding the henhouse", they called us a forest industry committee, which we're not. The bottom line is we know we're doing the right thing, and we know we are empowering landowners to secure their future, and ours.

As I close, I had hoped, and I'm still hoping, in the next eight days to inspire you to empower yourselves. It's your future, if you don't do it for you, it will be done to you. *Mahalo.*

Selecting Sites for Commercial Forest Operations

Bill Cowern, Hawaiian Mahogany Inc., and J. B. Friday, UH Mānoa CTAHR

The following are points to be considered when selecting sites for commercial forestry operations. In some cases, growers will be searching for a site to establish a business upon. In other cases, a landowner will start with an existing site and attempting to create a commercial forest business upon that site.

Climate considerations

- What is the site elevation? Elevation will influence both temperature and rainfall. Many tropical trees grow best at specific elevations.
- What is the rainfall history at the site? Are there occasional periods when rainfall is significantly lower than average and drought may be a problem?
- What is the distribution of that rainfall? Most areas in Hawai'i are drier in the summer, if at all, but some, for example Kona, are drier in the winter and wetter in the summer.
- How does that available moisture affect the site based on the soils and slope? Sites on moderate slopes will usually be better drained, but very steep slopes may be vulnerable to erosion. Clay soils hold moisture better than rocky or sandy soils.
- What is the level of average incident solar radiation on the site? Very rainy areas on the windward sides of the islands, and high elevation, cloudy sites will receive less sunlight.
- What are the temperature ranges on the site and what is the average temperature? Most tropical trees are sensitive to lower temperatures. Is there a danger of frost damage at high elevations?
- How exposed is the site to wind? Wind not only damages trees but increases water use and drought stress during dry spells.

Land and soils considerations

- What are the soil types on the site? Information on soil types, use classifications, and limitations is published in a soil survey. Soil surveys are more accurate for agricultural areas than mountain and forest areas. Soils vary greatly in structure and fertility across the Hawaiian islands.
- What are the existing nutrient levels and what other minerals will have an impact on the growth the desired tree species? While total levels of nutrients, especially N and P, may be high, how much is readily plant-available?
- What is the pH of the soils on the site? Most Hawai'i soils in moist or wet areas are acid, unless they have been heavily limed. Acid soils are poor at holding nutrients and may have toxic levels of aluminum or manganese.
- What is the drainage of the site and of the soils on the site? Many tree species do poorly in flooded soils, as their roots die from lack of oxygen. Poor drainage can be caused by impermeable plow pans or hard pans in the subsurface soil layers, as well as flat terrain.
- What are the physical properties of the soils? Are they easily eroded, easily compacted, or droughty?
- What types of erosion mitigation might have to be implemented on the site, either temporarily or permanently?
- What is the availability of water for irrigation, for process water, or for power?

Monetary considerations

- What are the annualized costs per acre for the land?
- What are costs of leases? Are leases available for the length of a forestry rotation?

- What are county property taxes?
- What other incidental costs need to be considered?

Incidental considerations

- What is the access to the site for routine work and maintenance? Are agreements needed for right-of-ways across private or public property?
- Will additional roads be needed on the site? Where will they be located?
- What is the access to existing processing facilities or the capability of the site to support those facilities? How easy will it be for a logger to access the site when it comes time for harvest?
- What neighbor issues, if any, exist? Will neighbors object to use of pesticides, fertilizers, or the eventual harvest of crop trees? Do the neighbors have livestock which run free and may damage young trees?
- Are there view plane issues, from either the point of neighbors or the county? Visualize what full-grown trees on the site will look like.
- What is the history of the site? Who used it previously, and what did they do? What crops were grown and what soil conservation measures were used?
- What previous chemicals were used? Are there any residues left on the site?
- Are there any zoning issues? Is the land zoned conservation or agricultural? Commercial forestry is not prohibited on conservation land but additional restrictions apply.

Even after all considerations are made, any site of any size at all will have micro-sites and within-site variation. Some locations will drain poorly, or have particularly rich soils, or will be over previous roadbeds or building locations. Exposure to winds, which both cause drought stress and physical damage to trees, can make a huge difference in site quality. Growers must accept some variability in tree farming operations, probably more than in most agricultural operations. However, good tree farmers will learn to adapt their management techniques to the peculiar demands of their land.

Selecting Seed and Seedlings for Working Forests

John Edson, Hawai'i Reforestation Co.

This paper focuses on how to select the best planting material for our farm forests and presents concepts and practices to think about as we start to grow timber trees. High value hardwood plantations should be designed to produce trees with good timber form and optimal yield of merchantable quality wood.

Healthy native forests naturally regenerate themselves primarily by seed. Seed rains down from the tree canopy to the ground; some of it germinates in favorable locations, and over time a very small number of those seedlings that are best adapted to this environment will grow to replace the old-growth canopy. To establish a new forest of commercial value in Hawai'i on open ground that was once forested with native trees but is now abandoned pasture, cane field, or weed forest will require human assisted or so-called artificial regeneration. The chance of creating a successful commercial forest is much more certain if the grower first makes a forestry plan. Initial questions invariably relate to decisions on the sorts of trees to be grown and information on seed or seedlings to be purchased.

Because commercial growers try to produce optimal volume of high-quality wood, timber trees generally appear different from ornamentals, shade trees, and orchard trees. Farm forests are not landscaped estates, shady backyards or arboreta. Forestry attributes that generally add commercial value to a hardwood include a tall bole that is straight, vertical, with a minimum of side branching, good diameter growth, minimum taper, a single leader, a vigorous well-developed crown of foliage, and freedom from disease. These characteristics can be achieved through a combination of best silvicultural (tree growing) practices, selecting appropriate spe-

cies, and using seed that has genetic potential to develop quality timber. However, some valuable hardwoods do not naturally have good timber form.

Growth and form of a tree depends on how its genes respond to the surrounding environment. In this context, growth means height growth, diameter growth, and overall vigor and form means general tree shape and appearance. Different environments can result in large differences in growth and form. For example, false kamani (*Terminalia catappa*) fully exposed to salt-laden tradewinds develops stunted growth and distorted form; but with minimal shelter, trees develop more normally. Toon (*Toona ciliata*), a member of the mahogany family, can develop excellent timber form, but like many commercial species does not grow well in shade. Light demanding (or shade intolerant) trees, such as toon, can be encouraged to grow tall straight boles in plantations by planting seedlings at close spacing with stocking densities of 400 or more trees per acre. In the low-light environment beneath the rising canopy, leaves die and branches detach from the bole. Although a branch-free bole has definite commercial advantages, there are many valuable species, such as pheasantwood (*Senna siamea*) that retain their lower branches. The lower branches could be removed by pruning. Trees with multiple stems and no bole, forked trunks, or defoliated crowns show poor timber form. Large crowns develop in open-grown trees at the expense of height growth. Rather than producing wood, these trees put their energy into fruit and seed production.

Species selected should, at the very least, tolerate the environment of the planting site. This involves a careful matching of site conditions such as moisture, tempera-

ture, soil composition, soil acidity, wind strength and prevailing direction, level of salt spray, and other factors with the range of available micro-sites. Each species should be evaluated for its ability to tolerate extremes within each environmental parameter. Moisture is of paramount importance; some species such as koa (*Acacia koa*) and red sandalwood (*Adenanthera pavonina*) are often damaged by drought stress. Honduran big-leaf mahogany (*Swietenia macrophylla*) growing in heavy soils can survive periodic extended drought, but strong tradewinds can bend trunks to produce both crooks in the bole and wrap-around branches in a distorted canopy. Teak (*Tectona grandis*) tolerates drought but not shade; it commonly drops its leaves during long dry periods to protect itself from moisture stress, but seedlings quickly die if covered by weeds in a new planting.

Assuming species have been appropriately matched with the microenvironments of the site, the best possible seed source needs to be found to grow a timber-quality tree. The seed should be healthy and vigorous, from a source adapted to environmental conditions similar to the site, and improved rather than wild seed where possible.

Seed collection must be managed carefully from collection to end user to ensure high quality seed. Timing of seed collection is critical. If collected too early, immature embryos won't germinate; if insects or other predators eat the ripe seed, the collector is too late. Even with a high-quality collection of ripe seed, damage can occur in handling and transport. Simply dropping or crushing a bag of seed or leaving it exposed to the sun or extreme temperatures could prove fatal. Good sanitation reduces incidence of disease. High moisture and unclean seed lots encourage fungal spores on seed coats to attack both seed and young seedlings. Germination rates of seed lots vary greatly with freshness of collection, storage conditions, species, seed source, and incidence of disease.

Most exotic hardwood seed is presently imported into Hawai'i. Local exotic seed sources are limited in supply and often of unknown quality. High costs of rapid transport from the country of origin, fund transfer charges to pay for the seed, phytosanitary certificates required for entry through customs, and customs brokerage fees usually far outweigh the price of the seed itself. Furthermore, because of lack of control over the perishable product in transit, the seed importer faces significant risk of receiving damaged or dead seed and high financial loss.

There can be extraordinary variation in tree seed between species in different families. Not surprisingly, striking differences in form of teak and big-leaf mahogany trees reflect these genetic traits. In comparing growth and form of *Swietenia* mahoganies from the American tropics and *Khaya* mahoganies from East Africa, large variation in leaf color and crown architecture can be observed within the single family, but similarities in seed and fruit are also easy to discern, strong evidence that they are closely related. These species likely derive from a common ancestor that pre-dated continental separation and drift of South America from Africa. Less obviously, considerable genetic variation can occur within a single species. Native teak grows across a wide geographical area from India to Laos and has adapted to very different environments, from sea-level to over 3000 feet elevation and in rainfall from 20 inches to over 200 inches per year. Growers should try to obtain exotic seed from a geographic seed source area, or provenance, with an environment similar as possible to the planting site. A coastal provenance, rather than an interior continental one, would be preferable for a coastal site; a high-elevation provenance would likely perform better on a high-elevation planting site than at low elevation. Close matches of provenance with seasonal rainfall patterns, total rainfall, latitude, altitude, and other factors will likely enhance success of the plantation.

Most forest tree species remain wild and show a lot of genetic variation, as opposed to agronomic species that have been domesticated by selection and breeding for millennia. Wild seed should be collected from mother trees with superior timber traits in order to grow trees of quality. However, pollen that reached a flower on the mother tree could come from one of any number of father trees of that species in the vicinity. Because the quality of the father is unknown and because genes mix at fertilization, there is no guarantee that any particular wild seed will inherit and express the superior qualities of the mother. The chances of obtaining seed with potentially superior timber qualities are improved when selections of superior trees are interbred in a seed orchard created expressly for that purpose. Improved seed is usually more expensive than wild seed and often more difficult to obtain.

Although private forest nurseries in Hawai'i offer both wild and improved seed for sale, most growers opt to buy seedlings ready to plant. Seedling quality can dra-

matically affect survival after planting. Nurseries growing forest trees use specialized containers to produce superior root systems. A root system that rapidly grows into surrounding soil is more likely to survive. The root mass of the seedling is commonly referred to as a plug and the entire plant as a plug seedling. A quality plug seedling will have a reasonably intact plug that is not significantly rootbound, shoots that are stocky and not too tall and spindly, and be free of weeds, pests, and disease. Seedlings with spindly stems are normally unplantable. Even high-quality stock plants may become unplantable if they remain longer in their containers than necessary. Because it becomes more and more difficult to maintain a rootbound seedling over time, growers should plan to plant when the seedlings are ready. Forest nurseries offer native Hawaiian plants for forest restoration projects, Polynesian-introduced and exotic hardwoods, shrubs, and groundcovers for forestry and agroforestry plantations, and clumping or non-invasive construction bamboos for an emerging bamboo industry. Growers should expect to order fast-growing plants such as eucalyptus or balsa seedlings in three months or less; slower-growing high-value hardwoods may take four to six months or more to grow in the nursery.

Vegetative propagation presently plays a small role in plant production for Hawai'i forestry. Clumping bamboos are propagated primarily from rooting cuttings and divisions. Less commonly, and often at greater cost, tree species with low germination rates or seed in short supply may be cloned. As forestry expands and matures in this state, growers will likely see increasing use of vegetative propagation of elite eucalyptus trees. Rooting cuttings and micro-propagating buds and shoot tips are essential techniques to bulk up stock plants in tree improvement programs.

Ultimate success in growing quality wood depends on following through with a plan that has chosen species well adapted to the site from the best provenance available. For acceptable survival and growth, seedlings should be planted when they are ready to plant. Develop a good plan if you don't already have one. Check with nurseries on how long it will take to produce the seedlings you need. Coordinate seedling orders with a schedule for preparing the site for planting.

Editors' note: For more information on seed collection and handling, see *Seed Technology for Forestry in Hawai'i*, UH-CTAHR publication RM-4, available free on-line at <http://www2.ctahr.hawaii.edu/oc/freepubs/pdf/RM-4.pdf>, or from Cooperative Extension offices.

Hedging Your Bets: Selecting Tree Species to Deliver a Continuum of Value

Bart Potter, C. Barton Potter Co.

Potter's talk featured detailed photos of many high-value hardwood trees that have done well in Hawai'i, as well as photos of woodwork made from those trees. Also included were historical photographs taken in the early 1900s of Hawaiian areas which have since been thoroughly re-vegetated and photos of recent plantings of koa throughout the state.

The talk also addressed ancillary benefits that trees can provide during their long lives before harvest and listed some of these benefits as watershed improvement, landscape enhancement, windbreaks, source of honey and pollen for beekeepers, source of propagules for future plants, and a source of shade for commercially valuable shade-tolerant understory plants such as coffee, anthuriums and edible fungi.

The species featured included some that are considered to be invasive pests in some areas of the state, begging a discussion on the seriousness of the individual threats, opportunities for harvest of existing pests, realities of management postharvest, and conditions under which such trees might be replanted.

The species featured were *Acacia koa*, *Rhizophora mangle*, *Fraxinus uhdei*, *Fraxinus americana*, *Tectona grandis*, *Eucalyptus citriodora*, *Khaya anthotheca* syn. *K. nyasica*, *Toona ciliata*, *Cedrela odorata*, *Swietenia macrophylla*, *Swietenia mahogani*, *Grevillea robusta*, *Cinnamomum camphora*, *Cinnamomum burmanii*, *Dalbergia retusa*, *Platymiscium pinnatum*, *Pterocarpus indicus*, and *Senna siamea*, syn. *Cassia siamea*.

Economic Analysis of Tree Farms

J. B. Friday

UH Mānoa, CTAHR Cooperative Extension Service

Tree growers, like any other farmers, need to be able to balance costs and benefits in order to make their farms profitable. Tree farms are exceptional, however, in that many years may go by before a grower sees any economic harvest, while the greatest expenses in establishing a tree farm occur at the outset. Markets for wood, especially high quality timber, change rapidly in comparison with how long it takes to grow trees. Tree farmers therefore need to know how to correctly discount anticipated future returns and balance them with present-day or intermediate costs. Initial costs involved in tree farming may include site preparation, weed control, fertilization, purchase of seedlings, fencing, and planting costs. Weed control costs may extend for several years. Intermediate returns may be had from thinnings or agroforestry products before the stand is finally har-

vested. Costs and returns for each year of a given project may be summed and the results discounted to the present and totaled to calculate a Net Present Value for a project. The financial worth of different projects, different species choices, and different management decisions such as rotation lengths and whether to thin can all be evaluated on the basis of comparing Net Present Values or Internal Rates of Return. As markets for stumpage (the value the uncut trees on the land) in Hawai'i will change as local harvesting and milling capacities expand, landowners need to also be able to conduct sensitivity analyses or "what if" calculations. Resources on financial calculations for tree farming are available at the CTAHR forestry extension website, <http://www2.ctahr.hawaii.edu/forestry>.

The following seven pages reproduce CTAHR publication RM-9 (Dec. 2000).

Financial Analysis for Tree Farming in Hawaii

J. B. Friday, Carol Cabal, and John Yanagida

Department of Natural Resources and Environmental Management

This publication provides information for tree growers, forestland managers, and forestry extension workers on how to estimate the economic value of trees and forestland.

Tree farmers in Hawaii grow trees for many reasons: for forest restoration, for conservation of native species, for recreation, and as a business. If you are growing timber as an investment, you need to be able to analyze the profitability of your business. Economic decisions tree farmers face include which tree species to grow, when to harvest, and when to replant. You may also wish to compare the financial benefits you would obtain from your forestry activity with those you would obtain from other land use alternatives, such as ranching or hunting. A key difference between the economics forestry and most agricultural land uses is that the financial returns to forestry are often delayed for years. Therefore, you need to take the time value of money into account when planning investments in forestry.

Financial calculations give you answers to hypothetical questions. You have to supply the growth rates, prices, and costs particular to your situation. The answers you get will be only as good as the data you use. You can think of financial analysis as a framework to organize your thoughts and help set directions. Following are answers to some questions that you might ask.

How should I value time?

In forestry, revenues include income from thinning and sales at harvest, while costs may include expenses for stand establishment, forest management, taxes, and harvesting. The value of time affects both revenues and costs. Revenues are worth more if earned earlier, while costs are less costly if incurred later. In long-term business projects, time thus has a complex effect on the value of revenues and costs and, hence, profits.

What is discounting?

The value of time is accounted for by applying an interest rate referred to as the discount rate. For example, suppose you have \$100 now, which you will invest for 10 years with a 6% annual interest rate, compounded annually. To find out how much your \$100 will become 10 years from now, you use the following formula:

$$FV = PV(1 + i)^n$$

where: FV = future value

PV = present value

i = discount rate

n = number of years

so you have: $FV = 100(1 + 0.06)^{10} = 179.08$

Thus \$100 invested today and earning a 6% annual interest rate will be worth \$179.08 in 10 years. This process of converting a present value to a future value is called compounding.

Likewise, you can also convert a future value to a present value by discounting. One hundred dollars to be received 10 years from now will be worth less today because of the time value of money. The formula to get the present value of \$100 to be received 10 years from now with a 6% annual interest rate is

$$PV = \frac{FV}{(1 + i)^n} = \frac{100}{(1 + 0.06)^{10}} = 55.84$$

Therefore, \$100 to be received 10 years from now is worth only \$55.84 today.

How do I measure profitability?

The example of calculating the present value of \$100 to be received 10 years from now illustrates how you can determine the economic value of your long-term forestry business. Basically, you balance your present revenue and costs (such as costs of site preparation and seedlings) against your future revenues and costs (such as revenues from thinning and harvesting). For each year of the project, you sum your revenues and costs for that year to come up with an annual net revenue. Each annual net revenue is then discounted by the appropriate number of years, back to the present. The sum of all the discounted annual net revenues gives you the net present value (NPV) of the project. Calculations of NPV can readily be done with computer spreadsheets or financial calculators.

If you have several forestry projects or other land use alternatives open to you, such as ranching or hunting, you can rank them by comparing their NPVs. The project with the highest NPV would be the most economically beneficial.

How does the internal rate of return (IRR) relate to NPV?

When you calculate your NPV, you select an interest rate (the discount rate) that you could earn if you invested your money in the next best alternative. In our example above, this was a 6% annual interest rate. The IRR, on the other hand, reflects the interest rate that you earn from investing in your forestry project. You calculate the IRR by finding the discount rate that makes the NPV equal to zero. The IRR is another measure of profitability that you can use to compare different projects or investments.

How should I account for inflation?

If you assume all prices and costs will rise at the same rate, you can leave inflation out of your calculations altogether. Real prices and real interest rates are those not adjusted for inflation. The interest rates offered by banks are nominal rates, which are real rates plus an adjustment to allow for inflation. If inflation is expected to be 2%, then the 6% nominal interest rate is equivalent to a 4% real interest rate. In your economic calculation, you may use real interest rates and prices or nominal interest rates and prices adjusted for inflation, but you must be consistent in any given calculation.

How should I account for the cost of the land?

If you own land and are deciding whether to grow trees or another crop, it is easiest to leave land cost out of the calculations, as it will be the same for all your alternatives. If you will be purchasing or leasing land as part of an investment in tree farming and you are considering other investments, you should include the interest on the mortgage or lease payments in your costs.

At what age should I harvest my trees?

Trees grow continuously, but their growth rate decreases over time. You should harvest when tree growth slows to the point that you would be better off harvesting and selling them and planting a new crop. Specifically, you should harvest when the trees reach their maximum NPV. You do this by calculating NPVs for all years in which harvesting could occur, then selecting the year for which the NPV is greatest. This is your theoretical optimum year of harvest.

The age when the trees are harvested is called the rotation. Rotations may be short (e.g., 12–15 years for some *Eucalyptus* species), or they may be long (e.g., 80 years for some slow growing, high-value hardwoods). Shorter rotation periods would result also from higher discount rates because of the relatively greater opportunity cost of leaving the trees in the ground longer. On the other hand, larger trees, although they take longer to grow, may be able to be sold at a premium because they can be used for high-value products, such as veneer.

In the real world, timber and stumpage prices cycle up and down. (Stumpage price is the value of timber as it stands uncut, i.e., the amount paid by the logger to a landowner for the right to harvest trees). To maximize net returns, you can delay harvesting if prices are low and wait out the cycle. Alternatively, tree farms can serve as “money in the bank” for future anticipated expenses such as school tuition.

Can I convert NPV to an annual basis to compare forestry with other land uses which could provide annual income?

Yes, there are two ways of doing this. First, if you plan to grow trees for only a certain period (e.g., 60 years), you can convert your NPV into an annual amount for 60 years. This is called the equivalent annual income (EAI) and the formula is

$$EAI = NPV \frac{i(1+i)^n}{(1+i)^n - 1}$$

where n is the number of years in the rotation (an example is shown below).

Second, if you plan to grow trees perpetually, you calculate a land expectation value (LEV). The land expectation value is the present value of a perpetual periodic series, and it represents the value of the bare land if used to grow trees. It is calculated as follows:

$$LEV = \frac{FV_n}{(1+i)^n - 1}$$

where

FV_n = net future value at the end of the first rotation and

n = number of years in the rotation (an example is shown below).

If you have already calculated the EAI, the LEV may be calculated as simply

$$LEV = \frac{EAI}{i}$$

You may use EAI and LEV to compare investments of different duration, such as shorter rotations and lower-value species versus longer rotations and higher-value species. You may also use them to compare annual incomes derived from forestry, where your income is delayed, to other land uses such as ranching or planting agricultural crops, where your income is received yearly. Since EAI and LEV are "annualized" versions of NPV, the investment with the highest EAI or LEV would be the most economically beneficial for you. Note, however, that the formulas presented here are just for a single stand of trees. A tree farm or forest, once established, will consist of many stands of trees of different species and different ages. These will be harvested at different times, giving a more constant flow of income. An economic analysis of an established tree farm with stands of many different ages would be a combination of the individual analysis for each stand.

A sample analysis of a teak tree farm in Hawaii

The following example shows how a particular grower might calculate expenses and returns on a tree farm. Teak was chosen as an example because it has been widely grown around the world, and its growth rates and rotation ages are relatively well known. The costs reflect typical expenses to establish a small (10–50-acre) tree farm on the island of Hawaii in 1999. Costs used in the calculations are given in Appendix 1. Larger tree farms will have economies of scale, which will lower per-acre costs. The only management cost included in the example is for a professionally prepared management plan at establishment. If a professional manager is employed for the life of the project, annual management costs need to be included. We have assumed that the landowner already owns the land and would be keeping it in agriculture in any case, so land costs (lease or mortgage payments) and property taxes are set to zero. Some counties in Hawaii offer low property tax rates if land is used for forestry. The difference between what you would otherwise pay and the forestry property tax rate could be counted as income. Income and capital gains taxes are not included in this analysis. If you enroll in a government-sponsored cost-share program, you will be eligible for rebates for part of your costs. *You should estimate your own costs*, which will vary depending on the soil type, accessibility of the site, its current vegetation, the cost of seedlings, and other factors. Clearly, it is important to keep good records of your costs and revenues if you want to be able to calculate the value of your investment in forestry. As your plantation grows, you will be able to substitute real costs for your estimated ones and make more accurate projections of growth and income.

Yields

Hypothetical yields in thousands of board feet per acre (mbf/acre) are given in Appendix 2 for rotation ages from 25 to 60 years. These yields assume that the entire plantation is harvested at one time. It would, of course, be possible to harvest one part of the plantation at one time and another later. In that case, the economic analysis should be done separately for each part. The yields given are conservative estimates for a well managed teak plantation, appropriately fertilized and thinned, growing in a low-elevation area receiving more than 80 inches of rainfall per year. Yield rates were based on a wide vari

ety of international trials, none in Hawaii. *You should create your own yield rates* based on your particular species and site conditions.

Stumpage prices

Teak is one of the most valuable woods in the world, with sawlogs selling internationally for \$1300 per cubic meter—about \$4300 per thousand board feet (mbf)—and finished lumber selling at \$15 per board foot in Hawaii in 1999. Teak lumber from rapidly grown plantations, however, may be of lower quality and may not be as valuable as the teak lumber from native forests on the market today. Stumpage rates here were estimated as being greater than stumpage for eucalyptus, about \$500/mbf and less than stumpage for koa, about \$2500/mbf in Hawaii in 1999. Stumpage in this example was assumed to be constant relative to prices in general. If you believe that timber prices will change in comparison to prices in general (i.e., that there will be a real price increase or decrease), you could increase or decrease stumpage prices (for example, ½–1 percent per year.)

The sample analysis below (Table 1) was carried out on a computer or electronic spreadsheet.

Net revenue and NPV

Annual net revenue is calculated as the sum of all revenue, if any, less all costs, for each year. Net revenue is negative until year 15, the second thinning, which is the

first year any income is received from the plantation. The annual cost of \$25/acre for maintenance for years 7–14 and years 16–34 is not shown here but was included in the calculations.

NPV was calculated by using the NPV function of the computer spreadsheet for the entire 35-year stream of net revenues. The spreadsheet function discounts each annual net revenue by the appropriate number of years and sums the result.

Sensitivity analysis

Using a spreadsheet allows you to change stumpage prices, growth figures, discount rates, costs, and other variables and quickly see how these changes affect your NPV (Table 2). Because you can only estimate future growth rates, discount rates, and prices, it is important to do these sensitivity analyses. Sensitivity analysis allows you to see how far off your projections will be if your initial assumptions are incorrect.

The effect of different discount rates (same stumpage price)

For every year, the NPV is lower with a 7% discount rate than with a 4% discount rate. This is because a higher discount rate decreases the value of eventual revenue, while initial costs remain the same. Indeed, at the higher discount rate NPV is negative (the tree farm loses money) at all but the highest stumpage prices.

Table 1. Sample annual net revenue and NPV calculations for a 50-acre teak plantation in Hawaii. Stumpage is assumed to be \$1,000/mbf, and the discount rate is 4%. Numbers in parentheses are negative.

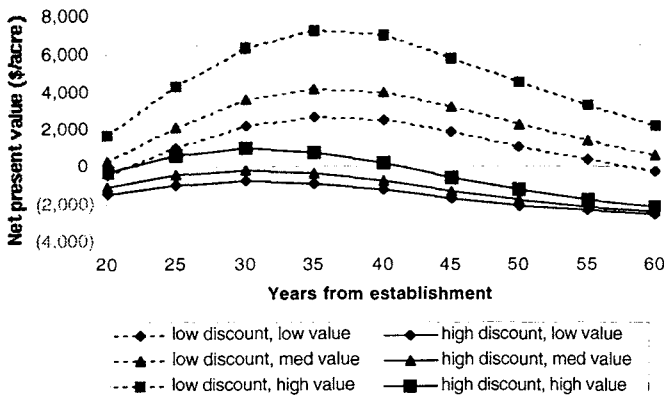
Year	Cost	Revenue	Annual net revenue
		\$/acre	
1	(2,255)	0	(2,205)
2	(230)	0	(230)
3	(230)	0	(230)
4	(230)	0	(230)
5	(325)	0	(325)
6–14	(25)	0	(25)
15	(25)	109	84
16–34	(25)	0	(25)
35	(25)	23,900	23,875

NPV = 2,713

Table 2. Sample sensitivity analysis of the NPV for a teak plantation in Hawaii. Maximum NPV for each scenario is in bold. Negative numbers are in parentheses.

Year	Stumpage					
	<u>\$1,000/mbf</u>		<u>\$1,250/mbf</u>		<u>\$1,750/mbf</u>	
	Discount rate					
	4%	7%	4%	7%	4%	7%
Net present value, \$/acre						
20	(387)	(1,424)	320	(1,023)	1,735	(222)
25	1,084	(915)	2,171	(381)	4,347	688
30	2,271	(694)	3,666	(99)	6,456	1,090
35	2,713	(846)	4,227	(287)	7,255	832
40	2,564	(1,191)	4,048	(716)	7,016	236
45	1,912	(1,625)	3,239	(1,256)	5,892	(518)
50	1,159	(2,003)	2,302	(1,727)	4,589	(1,176)
55	444	(2,299)	1,413	(2,096)	3,350	(1,691)
50	(192)	(2,522)	621	(2,375)	2,246	(2,079)

Figure 1. Finding the maximum NPV for a teak plantation in Hawaii for different stumpage rates and different discount rates.



You will notice that NPV reaches a maximum in each scenario and then declines (Figure 1). That is because tree growth rate is assumed to decline gradually over time, and after a time growth does not keep up with interest rates. You may also note that the maximum NPV with 7% comes earlier, at year 30, than the maximum NPV with 4%, which comes later at year 35. This illustrates that higher discount rates will result in shorter rotation periods.

The effect of different stumpage prices (same discount rate)

Unlike changes in discount rate, changes in stumpage price do not affect the rotation length. If stumpage price increases over time, however, the rotation becomes longer. This is because the rate of increase serves as an offset to the discount rate. The break-even price is the price at which the NPV at a given discount rate goes to zero. You may calculate a break-even price by entering various prices in the spreadsheet until the NPV becomes zero. For the example given, break-even prices are as follows:

Break-even prices at two discount rates	
Discount rate (%)	Break-even price/mbf
4	\$552
7	\$1292

Internal rate of return (IRR) calculations

As discussed above, the internal rate of return (IRR) is the discount rate at which the NPV equals zero. You may calculate IRR using the spreadsheet by trying different interest rates until the NPV reaches zero. For the three timber prices in the example, the IRRs would be as follows:

Internal rates of return at three stumpage prices

Stumpage (\$/mbf)	IRR (%)
1,000	6.0
1,250	6.7
1,750	8.1

Remember that these are real rates net of inflation; to compare with other investments, you would have to add anticipated rates of inflation to each.

Conversion to equivalent annual income

Let us say you plan to grow teak for a fixed period of 35 years and you would like to know your equivalent annual earnings for that period. With a discount rate of 4% and a stumpage price of \$1,000/mbf, your NPV is \$2,713 (see Table 1). To convert this to an annual amount, you determine your EAI as follows:

$$EAI = 2713 \frac{0.04(1 + 0.04)^{35}}{(1 + 0.04)^{35} - 1} = 145$$

This means that you would receive an amount equivalent to annual income of \$145/acre/year for 35 years. You may then compare this amount to another alternative source of annual income. The equivalent annual income may also be calculated using the payment function (PMT) on a computer spreadsheet. Along with the discount rate and number of years in the rotation, you should use the NPV as the loan amount. The payment function calculates a payment that is the same as the equivalent annual income.

Land expectation value (LEV)

The net present value of the tree farm is \$2,713/acre. The future value at 4% interest rate and 35 years is therefore

$$2,713 (1.04)^{35} = 10,706$$

The net present value of this and all other future rotations,

given the same production figures and costs, would be

$$LEV = \frac{10,706}{(1.04)^{35} - 1} = 3634$$

If the production figures, cost estimates, and prices are correct, the land is worth \$3,634/acre when trees are grown. If you have already calculated an EAI as in the example above, the LEV may be simply calculated from the EAI and the discount rate (*i*):

$$LEV = \frac{145}{0.04} = 3625$$

Slight differences are due to rounding errors.

Spreadsheet available

A computer spreadsheet with the above tables and other sample calculations for a tree farm in Hawaii is available for downloading from the CTAHR web site, <<http://www2.ctahr.hawaii.edu/oc/freepubs/spreads>>. The spreadsheet is written in Microsoft Excel format. The figures given in the spreadsheet are intended to serve as an example only. You must add your own data and projections to come up with reasonable predictions for your own tree farm.

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Appendix 1. Sample costs used in financial calculations for a small teak plantation (10–50 acres) on the Hamakua coast of Hawaii.

Establishment		
Management plan	50	\$/acre
Site preparation	200	\$/acre
Seedlings	2	\$/seedling
No. seedlings	435	seedlings/acre
Planting	150	\$/acre
Fencing	500	\$/acre
Herbicide application	160	\$/acre
Second herbicide application	160	\$/acre
Fertilizer application	165	\$/acre
Operations		
	\$/acre/year	
Weed control up to year 4	160	
Fertilizer up to year 4	70	
Maintenance starting year 5	25	
Management costs	0	
Land costs	0	
Property taxes	0	

Appendix 2. Hypothetical yields of a teak plantation on the Hamakua coast of Hawaii. Yields represent total volume of the plantation if clearcut in the given year.

Age	Yield (mbf/acre)
20	6.2
25	11.6
30	18.1
35	23.9
40	28.5
45	31.0
50	32.5
55	33.5
60	34.2
Thinning revenue	
No. stems cut at year 5	218 stems/acre
Price/stem at year 5	\$0
No. stems cut at year 15	109 stems/acre
Net price/stem at year 15	\$1

Protecting Trees with Windbreaks

Robert Joy, USDA NRCS Plant Materials Center, Moloka'i

High value hardwoods that developed in areas with high humidity and little wind may need wind protection in Hawai'i. High value forest products are a long term investment. Afforestation is occurring on former sugar cane lands exposed to high winds. Wind protection may be needed to protect the quality and value of these forests. We will discuss the basic principles of using windbreaks. Some old and relatively new species and how they may be used will be discussed. Each planting site will have its own ecological and climatic conditions. For specific information on a variety of species for windbreaks, contact your local NRCS, CES, or DOFAW office.

Windbreaks serve to protect new plantings, prevent wind throw, minimize breakage in strong winds, and maintain straight trunks. If we can protect tree plantations for the majority of their growth, or at least when they are young, we can produce straight, marketable timber. Various criteria must be considered if windbreaks are to be effective. If they are to adequately protect the forest trees, proper planning is necessary.

Species Choice

Species chosen for windbreaks should

- Grow rapidly
- Be adapted to the site
- Not tend to escape and invade native ecosystems
- Be pest-free
- Be taller than the crop trees

When selecting species for windbreaks, many things must be considered. Species that have proven themselves in the area are usually the best choice. They should grow faster than the forest trees, especially if they can't be planted well ahead of the forest trees. They should grow taller than the forest trees but may provide adequate protection if they protect the trees for most of their growth

cycle. Single row windbreaks are satisfactory if they are at least 50% dense, otherwise a double row may be needed. Windbreaks should have a density of 50–80% when viewed from the direction of the prevailing wind.

Neem (*Azadirachta indica*) is becoming a popular windbreak tree. It contains several useful compounds including the natural insecticide azadirachtin which is found mainly in the seeds but also in the leaves. There are natural insecticides on the commercial market using azadirachtin. Its potential commercial value may be a source of income, either as a seed source to establish neem plantations or for the seeds and leaves to extract azadirachtin. Neem can attain a height of 60 feet, has a moderate growth rate, and is adapted to areas that receive 20–50+ inches of rainfall annually. It can produce root sprouts or suckers, especially if the roots are injured by tillage equipment. Neem seeds are not viable for long. They generally remain viable for only 2–6 months in storage.

Dunn's white gum (*Eucalyptus dunnii*) is a relatively new windbreak tree in Hawai'i. It is becoming popular because of its symmetrical shape and rapid, straight growth. It should be adapted wherever eucalyptus grows well, basically above 100 feet elevation in mesic to wet climates. It tolerates frost but not salt spray. In Australia it is considered to be an important timber species.

The small cone ironwood (*Casuarina cunninghamiana*) has been a popular windbreak tree for many years. It has rapid growth, may reach 70 feet in height, grows from sea level to 3,000 feet, and is adapted to a wide range of rainfall and soils. Multiple rows will ensure adequate density but well cared for single rows will provide satisfactory wind protection. (*Editor's note: The more common horsetail ironwood, Casuarina equisetifolia, has become a serious weed pest in abandoned*

lands in Hawai'i. The small cone ironwood seems to be a less prolific seeder and is the preferred species for planting.)

Layout and Spacing

For maximum effectiveness, windbreaks should be aligned at right angles or 90 degrees to the prevailing troublesome winds. They may be planted between 90 and 45 degrees but if they are not planted perpendicular to the wind the rows should be spaced closer. At 90 degrees, the rule-of-thumb is to space the rows no further apart than 10 times the mature height (10 H) of the windbreak. For example, if the windbreak reaches 70 feet at maturity, the rows may be planted up to 700 feet apart. Windbreaks will not be effective for that distance until they reach maturity so it may be necessary to plant them closer and have the windbreaks take up more land or plant secondary windbreaks that use less space for wind protection in the early years.

A single row of ironwoods approaching maturity stands about 70 feet tall. For a tree farm, the windbreak rows would be approximately 700 feet apart. The trees planted between mature windbreaks would receive immediate wind protection. For this situation to occur, the windbreak trees must be planted years in advance. Planting closer together is another option. Growers of vegetables and other wind-sensitive crops space their windbreaks closer (5–6 H). They achieve earlier protection from their primary windbreaks in addition to greater overall wind protection but must devote more land to windbreaks.

'Tropic Coral' tall erythrina is a rapidly growing leguminous tree that can reach a height of 40 feet in approximately four years. It can be used as a secondary windbreak by planting it next to the primary windbreak (making a double row) and between the primary windbreaks at up to 400 feet between rows. It uses little space and will provide wind protection until the primary windbreaks are tall enough. It is basically a low elevation tree. It grows well from sea level to 1,000 feet but does best below 500 feet. It requires an annual rainfall of at least 50 inches, unless irrigated. It is easily propagated by cuttings planted directly in the soil. Cuttings can be planted through black plastic mulch.

Sorghum-sudangrass hybrids (*Sorghum* sp.) may be used as secondary windbreaks. It is best to use the sterile cultivars as they will not reseed. They grow 6–7 feet

tall in about two months and are adapted from sea level to approximately 3,000 feet. Above 1,000 feet, they should be planted only during the summer. If cut back to a height of 12 inches each year, fertilized, and irrigated (if necessary) they will last for about three years. They can be replanted as often as needed. Close (12-inch) double rows would be spaced about 60 feet apart.

Site Preparation

The amount of site preparation for the windbreaks would be essentially the same as for the rest of the tree farm. As for forest trees, it is important to prepare soil by breaking up hard pans and eliminating weed competition.

Planting

Planting the windbreaks would also be essentially the same as for the rest of the tree farm. As mentioned earlier, plant the windbreaks as far in advance of the plantation trees as possible so that they may provide wind protection as soon as possible. Use high quality planting stock. Consider using plastic mulch to prevent weed competition and irrigate and fertilize as needed.

Black plastic mulch or weed barrier will practically eliminate weeds from the tree row where they are the most difficult to control. Maintenance is reduced and moisture is retained. Mulch may be installed by a specialized machine which mounts on the 3-point hitch of the tractor and is designed to also lay a drip tube under the plastic. Planting through plastic is accomplished by making a hole in the plastic and planting through the hole. If the operation is done by hand and dibble tube stock is used, a dibble is used to make the hole in the plastic and the soil. Machines have been developed to plant through plastic mulch. The soil under the plastic must be tilled to a depth of at least 6–12 inches. Ripping or sub-soiling may be advisable prior to laying the plastic.

Maintenance

Maintain the windbreaks as a crop. In the case of a tree farm, the windbreaks should receive the same level of maintenance as the plantation or timber trees. Irrigate and fertilize as needed, control competition from weeds, and protect the trees from pests, grazing, and fire. While it is not normal practice to replant gaps in a plantation, it is important to replace dead plants in a windbreak as soon as possible. Otherwise wind funneling through the gap may do serious damage to the plantation.

Preparing Sites For Tree-Farming

Thomas B. Crabb

In the earlier technical sessions today you heard of some of the important initial decisions you need to make prior to starting any actual "hands-on" operational work in tree-farm establishment. Presentations on Site Selections, Seed and Seed Selections, Species, Windbreaks and Economics have all illustrated critical steps in coming up with a management plan.

In addition to subjects already presented pertaining to the development of your management plan I would suggest taking advantage of all other available services in each of your counties. Some requirements are mandated by law, such as obtaining a grading permit, and are easily complied with by becoming a cooperator in your Soil & Water Conservation District, with technical services available through the National Resource Conservation Service. Besides meeting your legal requirements, an approved District Plan would cover and meet all conservation concerns, a number of which are eligible for assistance through State and Federal cost-share programs. Later today you will hear of Planting, Fertilizing, and Stand-Management, all very important steps in the total success of tree farming.

Now the actual work begins...how should you go about it?

There are many basic steps to follow in the successful growing of any crop and site preparation stands out as one of the most critical. The question always asked is: how much is enough?

Once your management plan is established, your operational sequences would first start with preliminary pre-clearing. Then the actual clearing would follow which would include removal of weeds, heavy vegetation, trees

or shrubbery, and installation of conservation practices, followed by proper soil preparation (heavy disking and ripping) and bedding to encourage a good seed bed for proper root development. This would allow for good soil tilth, aeration and infiltration, conducive to optimal growing conditions. Pre-plant weed control could be considered a final step prior to planting.

With the basic purpose of this Symposium to present practical information on tree farming, so that it can be taken back to the farm for immediate application, considering what has and is currently being done could be helpful.

In order to assist you individually, a case by case study would be required to come up with specific methods to apply. For the sake of discussion or consideration some generalization may be helpful. Let us confine our thinking to farms in the 40 to 50 acre category and possibly up to 100 acres or more.

Pre-clearing would be advisable primarily for access, defining of boundaries and terrain observation, and to determine the farm layout. This would also allow for some thought as to how to approach and install soil conservation practices, if necessary. Rough matting-down or mowing of heavy vegetation could accomplish this. Clearing would then follow. Site selection would have a major impact on what would be required. Clearing is generally thought of by most people as removal, but in forestry site preparation not necessarily so. Any forested or extensively vegetated areas would require vegetation to be pushed into in-field wind rows or field edges, although this is a high-cost operation and may also contribute to soil loss. Costs of \$675 to \$700 per acre are not inconceivable, as experienced by BioEnergy Devel-

opment Corp. on the Island of Hawai'i (9 hrs. per acre at \$75 per hour). Non-removal is considered more acceptable and economical. Vegetation could be chopped up and incorporated into the soil by heavy disking. A one-pass operation could be accomplished for \$150 per acre (2 hrs. per acre at \$75 per hour) and double pass for \$300. This low-cost highly productive operation would have additional benefits in that it would also soften underlying soil, in some instances, preparing it for planting. Additionally, if a heavy enough layer of vegetation remained it could assist in weed control, moisture retention and erosion control. A high-powered crawler-tractor pulling a heavy-duty offset cut-away harrow with 36 inch discs has been quite successful. Conditions may require two passes or cross harrowing.

It would be appropriate at this stage of your tree farm establishment to install conservation practices in the form of diversionary ditches where soil movement may be a problem. \$50 per acre could accomplish this (2/3 hrs. per acre at \$75 per hour).

The third stage would be to determine the need for further soil preparation through soil profiling. In some soils a hard pan may exist, as experienced along the Hāmākua Coast on the Island of Hawai'i and by Hawaiian Mahogany Company here on Kaua'i. This has been common in abandoned sugar cane fields or where excessive in-field trafficking has occurred and created an impenetrable layer of soil approximately 12 to 18 inches under the surface. In this case a more extensive soil preparation by way of ripping designated areas to a depth of 24 to 36 inches would be required before planting. A single deep shank drawn by high-powered tractors or rubber-tired units could accomplish this. Cost estimates

would be in the neighborhood of \$75 per acre (1 hr. per acre at \$75 per hour).

The final operation would be bedding and would require a smaller track- or rubber-tired tractor with a rear end attachment of two angled-disks pulling soil in and forming a mound 6 to 8 inches over the area ripped throughout the field at the specified row spacing. Cost would be in the area of \$40 per acre (1 hr. per acre at \$40 per hour). In some instances where adequate soil preparation has been accomplished through heavy disking and not requiring ripping, bedding could still be done or eliminated.

The final step would be pre-plant weed control. Chemical weed control could cost \$50 per acre (0.2 hrs. per acre at \$40 per hour plus \$42 per acre for chemicals). Weeds could also be controlled by laying out polyethylene sheeting the length of the row and 2 to 3 feet wide or placing squares of individual matting for each seedling.

One common concern running through all these processes is that they require some high-powered expensive machinery, such as tractors in the 165 to 200 horsepower category and at a purchase price in the neighborhood of \$200,000. On an individual small farm, these tractors would be used only for a specific purpose and time and not needed thereafter. From an economic standpoint, such a purchase would be prohibitively expensive, but heavy equipment work could be parceled on a contract basis. The prudent way to approach preparing sites for tree farming would be to concentrate on the least amount of work and costs necessary to attain acceptable results. Options are available under varying conditions to achieve this and should be chosen selectively, and only as needed, to accomplish your purpose.

Planting a Commercial Tree Farm

Mike Robinson
Pāpa‘aloe Plantations

Landowners and managers interested in establishing a commercial tree farm embark on a journey of long term commitment and reward. The actual planting of the trees is probably one of the most satisfying tasks you can do in establishing a tree farm, and one of the most strenuous.

Just for a sense of scale, how many in the audience have ever planted a tree? If so, you probably know what I'm talking about when I mention the sense of accomplishment you feel at the end of a long physical day of tree planting. We've heard from earlier speakers about the importance of selecting good seed and seedlings, picking the right species for the right site, and how to protect your *keiki*, or baby, trees from the wind. Tree planters have the additional responsibility of ensuring that those carefully nurtured seedlings experience a smooth transition from their artificial nursery world into a tree's natural environment, the real world.

Before I get into the details of planting, however, I'd like to briefly discuss how important planning and timing is to the successful establishment of a tree farm. You must carefully think about your site and the effort needed to get seedlings growing in a nursery, having the site prepared, a windbreak in place, seedlings delivered to the site in numbers that can be planted on any given day, and post-planting maintenance and care. A calendar is perhaps your most valuable tool in the early stages of tree farm establishment. Table 1 is an example of a typical schedule that could be followed for establishing a tree farm. Dates could be adjusted based on the size of the farm, the number of seedlings that can be planted each day, and the level of effort needed to control weeds and maintain healthy trees. Other adjustment factors might include available resources (seeds/contractors/funding), climatic conditions (dry/wet seasons), and project phases (shade tolerant species/understory spe-

Table 1. Establishment schedule.

Activity	Approximate Time Period
Develop Site Plan	February 15, 2001 to March 10, 2001
Collect/Purchase Seeds	March 15, 2001 to December 15, 2001
Begin Seedling Production	June 15, 2001 to December 30, 2001
Prepare Site for Planting First Increment	September 30, 2001 to October 10, 2001
Begin Planting Seedlings	October 15, 2001 to December 15, 2001
Weed First Plantings	December 15, 2001 to December 15, 2003
Prepare Site for Planting Second Increment	April 15, 2002 to May 1, 2002
Continue Planting Seedlings	May 15, 2002 to July 15, 2002
Weed Second Plantings	June 15, 2002 to June 15, 2004
Monitor Health/Survival/Growth	ongoing

cies). The bottom line is that every tree plantation will most likely have its own set of conditions that need to be thought about, planned for, and implemented on a timely basis.

As part of your planning process, you should think through the full rotation of your trees. How many trees will be planted and what will be their spacing? What types of tools will be used to control weeds (*e.g.* mechanical vs. hand) and will that influence spacing? Will trees be thinned later on and how will they be harvested? Since planting is one of the earliest and more expensive elements of tree farm establishment, it can greatly influence your future income stream. Reducing or increasing tree spacing can change short and long term maintenance strategies and is therefore worthy of careful consideration.

The specifics of tree planting may not seem very technical at first, but there are considerations for maximizing your success. Just prior to planting, for example, you should prepare the seedlings for the site by "hardening" them. Exposing them to more sun or reducing their watering and fertilizing are examples of hardening techniques prior to planting. Proper care and handling of the seedlings in transport is critical. It doesn't make much sense to have well-grown, expensive seedlings leave the sheltered environment of the nursery in the back of a pickup going down the highway at 55 miles an hour. Imagine the desiccation and physical beating those fragile *keikis* take just getting to your farm.

Shelter your seedlings during all periods of transport, including in the field. Keep them out of the hot sun and high winds. Water them just before planting and keep the roots moist until they are in the ground. A common tree planting mistake is to remove the seedling from its container and lay it on the ground while the hole is being dug. This exposes fragile root hairs to the air and wind and can cause root die back in less than a minute. Remember that the tree is about to occupy a much larger "container" (the ground) and it may need every drop of water to get it through the next few days, or weeks, of drought. If nursery containers are removed well before planting to facilitate field handling, seedlings should be carried in bags or boxes that retain moisture and protect trees from the elements.

Often the best tree planting weather is during or after a gentle rain when the ground is moist. Soil moisture and

air humidity are high and the tree has additional time to establish its roots in its new home without undue moisture stress. Care must be taken during wet weather, however, to not "glaze" the planting hole sides with your tools, especially in heavy clay soils, because lateral root growth can be limited.

Planting holes should be deep enough to place the container portion of the tree even with or slightly below the surface of the ground. There are two categories of planting holes - compression and dug holes. Compression holes are most appropriate for smaller dibble tube or container stock. A shovel or *o'o* is inserted into the ground and a hole is pried open for the seedling. The dug hole is more appropriate for larger, bagged nursery stock as soil is removed from the hole for later use as fill. Regardless of the category, I usually dig deeper than necessary and back fill the bottom of the hole with loose dirt before placing the tree in the hole. This facilitates faster deep root growth.

A mistake I hear about too frequently is planters failing to remove the container or bag prior to planting. Tree roots need space in all directions except up. Channeling roots downward through a cut container bottom or protecting it "from those bugs" by leaving it in the bag are not good ideas. Once the container is removed, the tree should be quickly placed in the hole and the root mass covered to the level of the original container. Remove rocks and large pieces of woody debris from the fill as necessary. It is critical that roots placed in the hole are spread out in as natural a manner as possible. Forcing the tree into a shallow hole results in J-rooting or L-rooting. These planting errors can come back to haunt the tree farm manager, sometimes years later, as roots become malformed and can result in blowdown or mortality.

When the tree is placed in the ground in an upright position and with the roots extending downward and outward in a natural manner, soil must be compacted around the roots. Air pockets will result in roots dying and again potential mortality for the tree. Excess soil can be left around the hole, but should not be used to bury the tree stem.

Your trees are in the ground. They were healthy when planted, they received adequate moisture for at least a month, and now they're starting to grow. Now is not the time to walk away and ignore them, for in Hawaii, if

your trees are growing there is a good chance that other plants are growing too. Those in the vicinity of your trees are fighting them for light, water, nutrients, and space and must be controlled. Plan on at least one to three years of maintenance on your farm, depending on the type of weeds and grasses are in the area. This is such a critical area that we have a whole panel focusing on tree protection, so I'll leave it at that.

In closing, I'd like to remind you that establishing a tree plantation in Hawai'i is a long term commitment, but a relative one. Having planted, managed, and yes, harvested forests throughout the world, I can honestly say that the rewards of planting in a place like Hawai'i, where progress is measured in months, not years and decades like temperate forestry, are truly satisfying. Tree farming requires vision and an imagination that can see a forest of trees where once there was none. As we imagine the shade, the cool breeze rustling the leaves, and the sounds of nesting birds we realize it is all worth it, and that we should do it again, and again, and again.

Optimum Fertilization for Tree Plantations in Hawai'i

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Abstract

The decision to apply mineral fertilizers to supplement existing soil nutrients for tree plantations will depend largely on the economics of the cost of application versus the expected increase in growth and ultimately the benefits of greater marketable wood volumes at harvest. An awareness of the biological and environmental aspects of fertilization, however, is necessary to fully understand the response of trees and the soil to mineral supplements. This brief discussion will examine some of the biological and environmental factors surrounding optimum fertilization schedules of inorganic supplements and alternative methodologies of supplying nutrients for tropical forest tree species. Application scheduling of inorganic fertilizers will largely depend on soil nutrient profiles and tree growth stages. Other factors to consider include site and soil physical characteristics and annual phenological and environmental patterns. An alternative to inorganic supplements would include the use of nitrogen fixing trees (NFTs). On the Big Island, inter-cropping of an NFT with *Eucalyptus saligna* resulted in the greatest production of *E. saligna* per unit ground when the NFT comprised 50% or more of the admixture. Additional benefits of using NFTs are enhanced soil carbon formation, biological diversity, and reduced nutrient losses from soil leaching. As in traditional agricultural systems, however, the use of a particular nutrient supplement strategy will largely be determined by economic costs and benefits.

Introduction

There are three aspects to consider when discussing optimum fertilization practices for tree plantations in Hawai'i. Understanding the *biology of tree growth* is fundamental to understanding not only how an individual

tree responds to nutrient additions but how groups of trees respond as a stand when natural competition is introduced into the equation. The *economics of fertilizer use* from simple unit cost (\$/bag) to transport and application costs of equipment and labor balanced against investment returns (i.e. growth and final yield) will dictate for most landowners how or even if inorganic fertilization is an option.

Of paramount importance is understanding the *environmental considerations* of fertilizer applications, both inorganic and organic, on the larger scale of ecosystems or land uses. On a global basis, contemporary forestry has moved beyond management of individual groups of trees (or stands) to how the managed forests fit in on the landscape pattern of different land uses. This is extremely important in Hawai'i, given the State's unique geological, geographical, and evolutionary biological history. Aspects of fertilizer application practices and the economics involved are beyond the scope of this paper. Instead this discussion will largely focus on the growth response of individual trees and tree stands affected by the addition of plant nutrients followed by an example of the effects of intercropping with a nitrogen-fixing tree.

Biological Aspects of Tree Crop Fertilization

Optimum tree crop nutrition basically means that adequate nutrients are available to allow for rapid growth during the stages of stand development when nutritional demands are greatest. If nutrient availability is limited during this time then yields at harvest time will be affected. This is due to both the pattern of individual tree growth and cumulative growth of a group of trees. For an individual tree, soil nutrient uptake efficiency and nutrient use efficiency are important, while at the stand

level total nutrient demand has to be considered. The standard soil tests available through the University of Hawai'i Agricultural Diagnostic Service Center or any number of private laboratories around the state can provide the basic information on the levels of the macronutrients nitrogen (N), phosphorus (P), and potassium (K), as well as the important micronutrients and soil acidity or pH level. Procedures using soil tests to develop fertilization plans are described in Miyasaka et al. (1983). In all instances, however, the availability of soil water from precipitation or irrigation will be a controlling factor on soil nutrient availability and maximum potential production.

The three general stages of stand level growth to consider are establishment, rapid growth and maintenance. For the purposes of plantation management, however, these can be further simplified to the periods before and after canopy closure. *Canopy closure* occurs when the crowns of individual trees actually touch each other. Before canopy closure, during the establishment stage, each tree generally has a full canopy and is able to grow as rapidly as its neighbors. There is usually little nutrient accumulation in the biomass during this period as the trees are small and are putting much of their energy below ground for establishing the root systems to acquire the essential soil nutrients and water needed for developing a leaf canopy. Fertilization during planting and the establishment stage thus serves to provide for good root zone development. One typical recommendation for fast-growing *Eucalyptus* species on the Hāmākua coast is a split application (N,P,K) of 4 oz. or 100 grams per tree each at planting and again within six months (Whitesell et al. 1992). Applied nutrients may be lost due to leaching in high rainfall conditions, taken up by weeds, or taken up by the trees, but there is little effect on long term soil fertility of the site.

Long term fertility of the site will be determined by the inherent chemical and physical properties of the soil and the fertilization regime. Fertilizer recommendations developed for *Eucalyptus* spp. based on existing total soil N contents of <0.45%, 0.45% to 0.60%, and >0.60% are 570 kg/ha, 350 kg/ha and 260 kg/ha, respectively, applied in several applications over four years (Whitesell et al. 1992). These recommendations would generally also apply to other extremely fast-growing hardwoods, given that nutrient demand is directly related to growth; slower-growing trees would require less fertilization. The

greater the growth the greater the demand and the greater the amount of fertilizer that will have to be applied if production is to be optimized. Specific recommendations for potential plantation tree species other than *Eucalyptus* species, however, have yet to be developed in Hawai'i and would need an intensive set of field fertilization trials for each species (Binkley *in press*).

Once the stage of rapid growth begins after the trees are established, but before canopy closure, nutrient absorption will be proportional to biomass production. This is perhaps the most critical period for fertilization. Production and nutrition are directly related through leaf photosynthetic rate, canopy leaf area, and above versus below ground biomass allocation. In particular, N fertilization will increase production by increasing photosynthetic rates of individual leaves and will also increase growth by supporting more leaves and a larger canopy. This is important because it is the actual leaf area that a canopy can develop that provides the "engine" for growth. The total tree growth is the sum of all the photosynthesis of all leaves within the canopy. Individual trees with larger, fuller leaf canopies will have higher growth rates. For plantation tree crops, however, uniformly high production of all individual trees is the goal. Wide variation in individual tree diameters typically means a few large individuals dominating many smaller, growth-suppressed trees, which reduces not only final timber yield at harvest but also increases the costs of harvesting. It is thus critical to match the supply of nutrients with both the physiological demand of an individual tree and the total demand of a stand of trees. Additional N may also change the allocation of the additional carbon gained through photosynthesis. With more soil N availability fewer roots are needed to "mine" the soil for N and thus the tree will put more effort into aboveground growth. Results from nearly 200 eucalyptus plantations in Brazil showed that trees producing 50 tons/ha/year of total aboveground biomass took up 150 kg/ha/yr of N (Gonçalves et al. 1997). Although N may be the nutrient that most affects growth, adequate supplies of P, K, and calcium are also needed to allow the additional N to have the greatest effect.

After canopy closure within a stand there are only small fluctuations in biomass nutrient content with some fluctuations due to seasonal variation in phenology and weather. Since stand leaf area maximizes soon after canopy closure, what nutrient accumulation occurs is

greatest in the tree stem with 20 to 40 kg of N (out of a total of 150 kg N taken up) accumulating annually in the stem wood of fast-growing eucalyptus trees (Binkley *in press*). Also occurring during this time is an equilibrium in litter biomass production. Leaves are replaced at the same rate at which they are shed. Following canopy closure, a large proportion the nutrient requirements of a tree are met through internal cycling or retranslocation. In the case of N this means that once the leaf matures and then shaded out by new leaf growth in the surrounding canopy, the N moves from the old leaves to the new growing leaves, usually at the top of the canopy most exposed to the sun. The same situation exists for other "mobile" or "labile" nutrients such as K.

The distribution of nutrients in a stand of trees can be seen in the example presented in table 1. The majority of the N and a large proportion of the K and Mg is found in the leaves, where the nutrients are constantly being used and then moved where demand is greatest. In contrast the majority of the P is tied up in the stem and bark and is much less mobile within the tree. The other way to look at the total nutrients within a stand are the absolute amounts as shown in table 2. The amounts of N, K, and Ca approach 200 kg/ha while amounts of P and Mg are much lower. The aboveground requirements of trees will thus need subsequent, repeated fertilizer applications to maximize or sustain tree wood growth over time. For optimum canopy closure during the first year of *Eucalyptus grandis* growing on the Hāmākua coast, Santo (2000) recommended 200 lbs N per acre distributed among four to six applications. Where multiple species are utilized within the plantation differences and similarities in nutritional requirements will have to be considered.

The decision to fertilize with traditional mineral applications is typically done to correct known nutritional deficiencies, where the trees are to be established on overall poor soil conditions, and of course to stimulate growth during a period when the trees can best respond to the supplemental nutrients. Timing of fertilization is an often ignored consideration in plantation management but can critical to achieving the most benefits. Fertilization and the decision process are developed in Fisher and Binkley (2000).

Use of Nitrogen-Fixing Tree Species

An alternative to supplemental mineral nutrient application of nitrogen is the use of nitrogen-fixing trees (NFTs) intercropped with the main crop tree species. Biological N fixation in tree species occurs through a symbiotic relationship between the roots of trees and certain species of bacteria in the genera *Rhizobia*, *Bradyrhizobia*, and *Frankia* (Binkley and Giardina 1997). The bacteria make N available to plants ("fix" N) by removing N₂ gas from the atmosphere or air within the soil pores and converting it to ammonia (NH₃) which is then processed into proteins and other biochemicals (Fisher and Binkley 2000). In turn, photosynthesis allows the tree to supply carbon for the development of the bacteria within the tree's root system. Tree roots also often form associations with soil fungi known as mycorrhizal fungi. The tree supplies carbon for the development of the mycorrhizal colony around the tree's root system while in turn the mycorrhizae help to increase the supply of water and nutrients to the tree by expanding the adsorptive surface area of the roots. The most direct effect of biologically fixed N on crop trees is an increase in height and total biomass. Results from a series of field evaluations on the Hāmākua coast of the Big Island of Hawai'i using the NFT species *Falcataria moluccana* ("albizia") and *Eucalyptus saligna* as the crop tree showed a 50% increase in height of *E. saligna* in mixed plots as compared to pure stands. Woody biomass of *E. saligna* (which translates into wood volume production) was nearly two-fold greater in plots where the ratio of *Eucalyptus* to *Falcataria* was at least 50/50 (DeBell et al. 1997).

The benefits of biologically fixed N are that it is organic, the N is continuously available to the crop tree, and the N is available in moderation or at a supply rate that matches the rate of uptake by the crop tree. In a contrast, traditional mineral N fertilization is inorganic (derived from fossil fuel energy based manufacturing), delivered in a single large pulse (only a small percentage is actually taken up with the remainder often lost to leaching), and has relatively short term effects (the growth spurt will decline as the nutrient is used up). Additional benefits of N fixation include an acceleration of overall nutrient cycling, particularly for N. Nitrogen-fixing trees usually have higher leaf and branch N, and when leaves and branches are shed and decompose, soil N availability increases. Most NFT species

have leaves that decompose rapidly.

The use of NFTs could be considered where soil N availability significantly limits growth, the NFT chosen has substantial rates of N fixation, and when the use of the NFT presents no or little competition to growth of the main crop tree. A good discussion of these and other considerations of using NFTs in tropical agroforestry production is presented by Elevitch and Wilkinson (1999). Work over the past twenty years in Hawai'i has demonstrated good potential for using NFTs in timber production systems for a few species but the knowledge base is still limited. Implementing large-scale operations with any species, however, will require attention to phosphorus fertilization strategies, and perhaps most importantly, wood properties and marketability of wood products (Binkley and Senock *in press*).

Finally, operational production systems should seriously evaluate the larger scale environmental considerations of the invasive potential of exotic NFT species. Control of invasive plant species will receive increasingly greater attention in Hawai'i and their use in commercial operations will be questioned. A potential solution may be found in the development of seedless varieties that maintain high N-fixation rates such as has been done with *Leucaena K1000* but also maintain quality wood production (pers. comm. J. Brewbaker). In addition to the concerns about out-migration of tree species from planted forests, however, the potential of spread through "clonal" or root sprouting should also be identified.

The development of an ecologically based timber production system in planted forests using NFT species that fit within the environmental constraints of Hawaiian ecosystems would be a significant contribution to the sustainable management of the islands' agricultural soil resources and the local communities that depend on them. Site productivity of soil resources has generally improved where management has focused on forest resources (Powers 1999). Continued conversion of agricultural lands formerly under sugarcane to tree plantations throughout Hawai'i is likely to continue as land-owners begin considering the potentials of wood based products. Once a forest canopy is re-established land-owner options increase for sustainable management of soil nutrients regardless of chemical or alternative fertilization schemes.

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Table 1: Percent nutrient content of a 4 year old *Eucalyptus saligna* plantation (Poore and Fries, 1985)

Component	Nutrient (%)				
	N	P	K	Ca	Mg
Trunk	12	49	24	8	14
Bark	8	9	15	27	30
Branches	17	14	26	34	17
Leaves	63	28	35	31	39
Total Tree	100	100	100	100	100

Table 2: Mass nutrient content of a *Eucalyptus saligna* plantation (Poore and Fries, 1985)

Component	Nutrient (%)				
	N	P	K	Ca	Mg
Trunk	21	12	42	17	6
Bark	13	2	26	57	13
Branches	30	3	45	69	7
Leaves	107	7	61	64	17
Total Tree	171	24	174	207	43

Stand Management: Thinning and Pruning Forest Trees

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Tree farms usually start out with many more trees planted per acre than are eventually harvested. Stands of trees are usually planted with 450 to 700 trees per acre with only 50 to 200 destined for harvest. Stands will thin themselves out naturally, but if you manage the process you'll end up with healthier stands and more merchantable timber, and trees will reach merchantable sizes more quickly.

A given site can produce only so much wood. The wood, however, can be distributed among many, small trees or fewer, larger ones. Figure 1 shows basal area of several different stands in a 15-year-old *Eucalyptus saligna* spacing study on Maui (Walters 1980). Basal area is the cross-sectional area of all tree stems taken at breast height and is one index of the amount of wood in a stand. Note that while the closer-spaced stands have many more trees per acre, the basal area of the closer-spaced stands is only a little greater than that of the wider-spaced stands. Figure 2 shows that the wider-spaced trees have larger diameters. Larger trees are more valuable to the timber grower because a larger tree will yield more useable lumber than two smaller trees of equal biomass. While the closer-spaced trees will yield more pulpwood (figure 3), the wider-spaced trees will yield more sawtimber (figure 4).

In a plantation, seedlings grow up and out until crowns "close", that is, crowns of neighboring trees touch each other. Soon after this, the stand will have as much leaf area as it ever will, and subsequent growth just raises the canopy further and further off the ground, as trees compete with each other for sunlight. As trees grow taller, lower branches are shaded out and drop off in a natural process called "self-pruning." Some species of trees are

tolerant of shade and crowding. If left unthinned, plantations of these species will tend to become overstocked and individual trees will grow tall without adding much diameter. Stands should be thinned after the lower branches are shed from the butt log but before growth is lost from competition. If stands are thinned too early and trees are too widely spaced, trees will remain branchy and no clear wood will be produced on the stems. If stands are thinned too late, when the crowns of the trees have already shrunk to a small tuft of leaves on top of a tall stem, the trees will not be able to recover and add much growth after thinning. Stands of very tall, thin trees are also more susceptible to wind throw during storms.

Juvenile hardwoods tend to have a straight stem with many small branches, although this is truer for some species such as mahoganies and eucalypts than for others such as narra (*Pterocarpus indicus*). Once the tree approaches its mature size, however, the crown breaks up into many branches and you can no longer see a main stem. The bole below the base of the crown contains most of the merchantable sawtimber in the tree. One thinning strategy is to keep stands dense at first to promote height growth and then thin to promote healthy crowns and diameter growth after the tree approaches its mature height and the crown breaks up into many branches.

With the hundreds of species of trees grown in Hawai'i in a myriad of different sites, we don't have established thinning guidelines. On a given tree farm, a manager might choose to thin at ten years by selecting crop trees in the stand and removing those trees which compete with the crop trees and by removing (or killing) poorly formed trees. Five years later, a second thinning might

yield some income through selling the thinnings as posts or as small-diameter timber. Figure 6 shows how a stand might develop.

In determining which trees to thin, first determine your ideal spacing between crop trees. Large trees such as rainbow gum (*Eucalyptus deglupta*) will of course be more widely spaced than small trees such as pheasantwood (*Senna siamea*). Your end products also determine optimal spacing. Narrow spacings are used for biomass and pulpwood production, whereas wide spacings are better for producing sawtimber and veneer. Next, go through your stand and select the best trees in the stand as crop trees, keeping in mind your desired spacing. For example, if you planted at a 10 by 10 foot spacing (436 trees per acre), but your eventual spacing should be 20 by 20 feet (109 trees per acre), you may want to start out with a 50% thinning. The art is to select the best trees while keeping approximately to your desired spacing. Thin to release these crop trees from competition. Remove any large "wolf" trees which are branchy and forked and are dominating better-formed neighboring trees, unless they are valuable as wildlife habitat. Don't worry about smaller trees which are already overtopped. In sun-loving plantation species, these will eventually die out and won't compete much with the crop trees. If your trees are large enough, thinnings may be merchantable for posts or poles. If you don't intend to sell your thinnings, it may be more cost effective to kill trees by girdling and allowing them to die in place than to fell them. Be aware that dead wood overhead is a safety hazard if people will be entering or visiting the stand, though. A lot of dead and dying trees in a stand may also attract harmful insects.

The only natural forests in Hawai'i which are managed for timber are koa. Koa may regenerate in extremely dense stands with thousands of trees per acre after scarification or after a fire. These stands naturally thin themselves over time. One stand on windward Mauna Loa went from over 10,000 seedlings per acre after scarification to only 500 trees per acre 20 years later. Unfortunately, nature allows many poorly formed and branchy trees to dominate the stand. The natural thinning process may also be very slow to reach a final desired density. Managers may improve timber yield from koa stands by selecting quality trees as crop trees and thinning to release these from competition.

In mixed species stands, you need to think about which species you want to thin out first, especially if they are growing at different rates. If a stand consists of a valuable species mixed with an unmarketable one, clearly the lower-value species should be thinned to allow the more valuable trees to grow if you wish to maximize your economic return. For example, tropical ash (*Fraxinus uhdei*) and koa compete with each other, but koa is much more valuable. In a mixed stand, it would be wise to remove any ash trees competing with the koa. If one species is overtopping or otherwise out-competing the other, you may want to remove it before the other's growth is severely reduced, especially if the overstory species can be marketed. On the other hand, there may be ecological or silvicultural benefits to maintaining a mixed stand. An understory of a nitrogen-fixing tree may be improving the soil fertility of the site and improving the growth of an overstory timber tree.

Pruning timber trees is often done along with thinning as a part of stand management. In Hawai'i forestry, however, pruning is over-emphasized, perhaps because of our horticultural background. The goal of pruning is to help trees develop straight boles without branches which will produce knots in the lumber. In order for pruning to be financially viable, there must be a market premium for clear wood. Pruning is expensive, so it only makes sense to prune crop trees. It is a waste of time and effort to prune trees which will eventually be thinned from the stand anyway or which are forked or badly formed. Some timber species, for example narra, require more pruning than others.

When pruning, don't remove more than one-third of the live crown of the tree. Over-pruning will severely set back a tree's growth and may kill the tree. Prune when trees are still young (4 to 6 inches in diameter) so that the tree will be able to grow a layer of clear wood over the knots. When cutting individual branches, cut just outside the branch collar (figure 7). The branch collar is part of the bole of the tree; injuring this may lead to lasting damage of the bole. The size of the branch collar will differ with different tree species; look for where a dead branch meets the bole to see where the branch collar is on your trees. On the other hand, don't leave branch stubs, as these may be an entry for insects and disease and any way will slow the formation of clear wood. You will know you have done a good job pruning when the woundwood forms a circle around the base of a cut

branch. If the woundwood forms a U-shape or a shape like a pair of parentheses, the cut was made too deeply. Large branches need to be cut using three cuts (figure 8), although you are unlikely to get much clear wood from a log that has had such large branches pruned from it. First, cut the bottom of the branch a couple of inches away from the branch collar to prevent the branch from falling and tearing the bark down the bole of the tree. Then sever the branch with a cut from above that meets the lower cut. Lastly, cut the stub off at the branch collar. For more information on pruning trees, see Mead and Hensley (1998).

Good forestry is an art as well as a science. Thinning and pruning work together in stand management to produce timber and maintain healthy trees. Use your imagination to envision what you want your stand to look like in the future and guide it there.

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Figure 1. Density and basal area of *Eucalyptus saligna* plantations at different spacings on Maui.

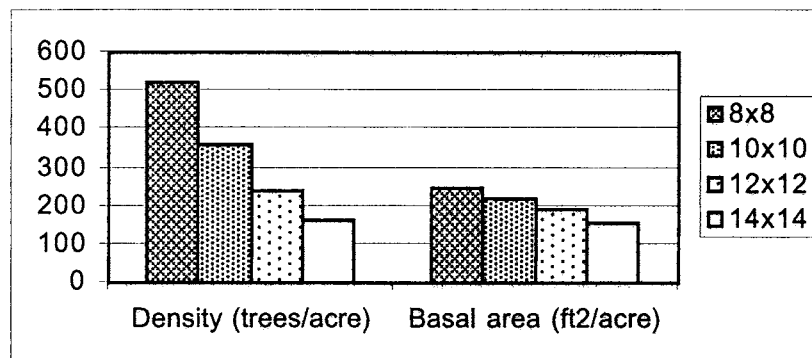


Figure 2. Diameter at breast height of *Eucalyptus saligna* plantations at different spacings.

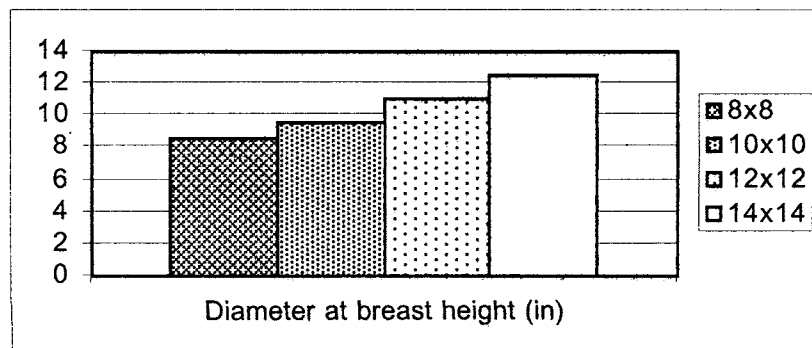


Figure 3. Pulpwood of *Eucalyptus saligna* plantations at different spacings on Maui.

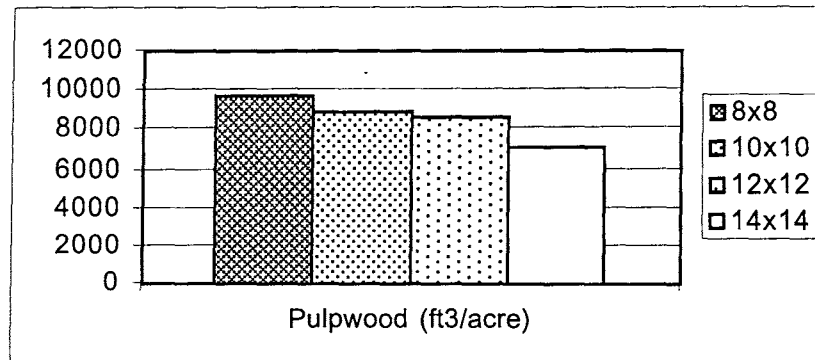


Figure 4. Sawtimber yield of *Eucalyptus saligna* plantations at different spacings on Maui.

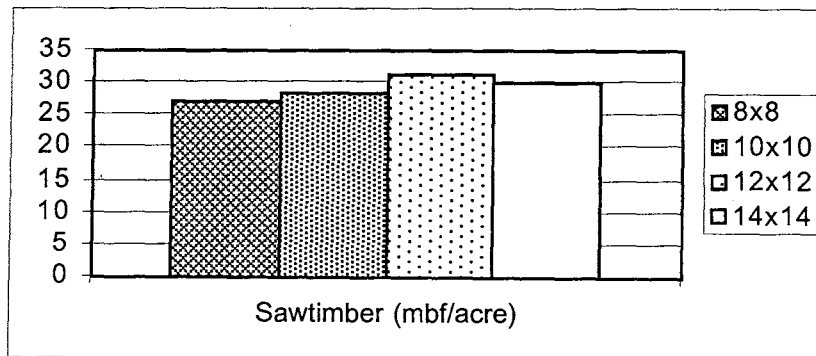


Figure 5. Longer logs yield more usable wood, measure in board feet, for the same amount of total wood volume, measured in cubic feet.

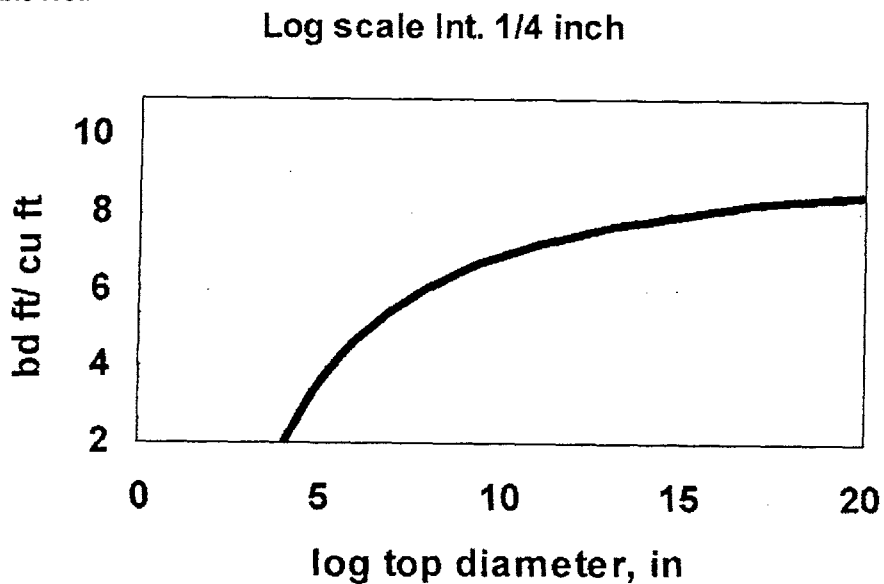


Figure 6. A typical stand, showing a) the unthinned stand at 10 years, with trees to be cut marked in grey, b) the same stand after thinning, and c) the same stand 5 years later, with the next trees to be thinned marked in grey.

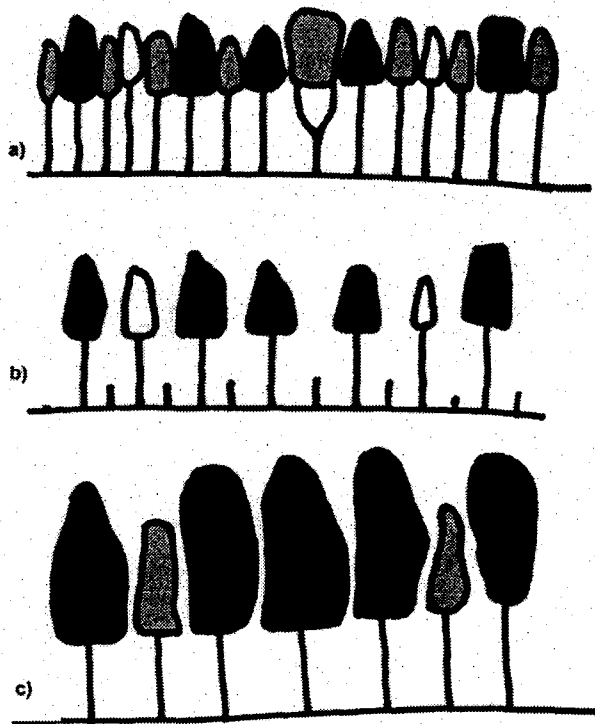
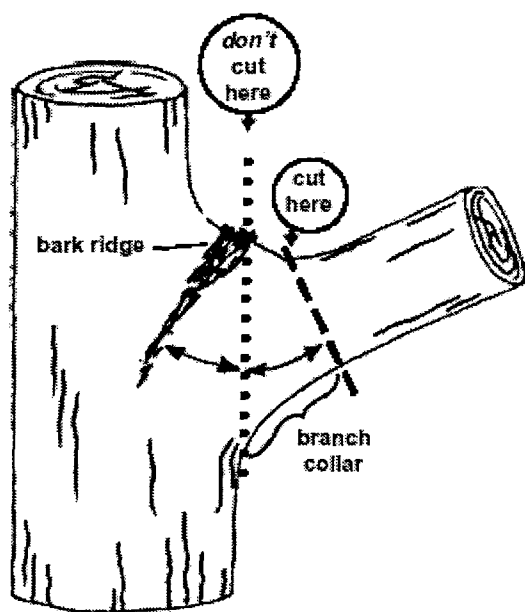


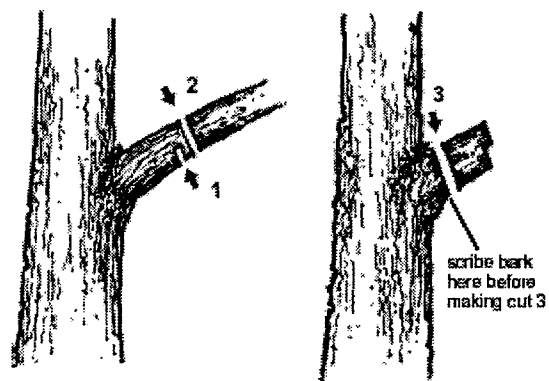
Figure 7. Locating the branch collar. From Meade and Hensley (1998)



Never cut a branch flush to the trunk. Begin the cut outside the bark ridge and angle it away from the trunk to avoid cutting the branch collar.

Figure 8. Make three cuts to prune a large branch. From Meade and Hensley (1998)

Three steps to pruning a large branch.



Panel on Tree Protection: Tree Diseases

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Because timber trees take many years to mature and are planted over large areas, disease management for tree farms needs to focus more on prevention than on control. Chemical sprays are not usually economical to apply to forest disease situations. Therefore, understanding of environmental and ecological requirements of a particular species is extremely important *before* planting in a particular site.

A disease is defined by Agrios (1988) as a "Mal-functioning of host cells and tissues that results from their continuous irritation by a pathogenic agent or environmental factor and leads to the development of symptoms." Diseases usually result in abnormal changes in form, physiology, integrity, or behavior. All diseases are not bad; for example, color breaking of tulips, caused by viruses, is highly desirable and valuable.

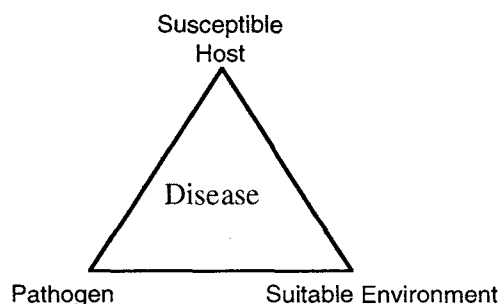
Diseases can be separated into two types based on causal agents: abiotic (non-infectious) or biotic (infectious). Abiotic diseases are basically an effect of the environment, over a period of time, on the tree. Common examples are:

- Too much or lack of water (e.g. underlying hardpan, poor drainage; drought)
- Nutrient deficiencies or toxicities (e.g. in nurseries)
- Too high or low temperatures (e.g. planting at too high or too low elevation for the species)
- Lack of oxygen (usually in conjunction with poor drainage)
- Pesticide toxicities
- Air pollution (e.g. in Hawai'i by vog)
- Too little or too much light (e.g. planting shade intolerant species in shade)
- Cultural practices (e.g. planting too deep, inadequate site preparation, pruning wounds, mechanical injuries)

Biotic (infectious) diseases are those caused by living organisms such as:

- Fungi
- Bacteria and phytoplasmas
- Viruses and viroids
- Protozoas
- Nematodes
- Higher plants (mistletoe and dodder)

The concept of the *Disease Triangle* states that in order for a biotic disease to occur, three factors must be present: a susceptible host, a suitable environment, and a pathogen. If any one of the three factors is absent, disease does not occur. Forest and tree disease management



programs must, therefore, take this concept into consideration. For example, the *host* can be "modified" by selecting the proper species or provenance for a particular site, bred for resistance or tolerance to a particular disease, or grown from seed selected from the proper elevation (e.g. different populations of koa are adapted to different elevations). The *pathogen* can be excluded from a specific geographical area through regulatory measures, and in nursery situations, by physical barriers or pasteurization of planting media. Since all patho-

gens require a specific set of *environmental conditions* to cause disease (spores to germinate, seeds to germinate, eggs to hatch, penetrate into the host, become established in the host, produce more infective propagules, etc.) selecting the proper tree species for a particular site is very important for the trees to survive for the planned duration of the planting with a minimum of problems. Understanding the biology of the host and of potential pathogens, before planting is crucial to growing a healthy stand. In forest pathology once the trees are planted, managing the disease is usually more practical than trying to eliminate the pathogen.

Tree diseases can also be classified based on whether the pathogens are native or exotic. Native diseases are usually not devastating because the pathogens and hosts evolved over a period of time interacting with each other; so typically, the host has developed some level of resistance or tolerance to the pathogen. Local examples are koa rust (*Endoraecium acaciae*) and the koa mistletoe (*Korthalsella complanata*). Both diseases are quite prevalent in koa stands but infrequently cause tree mortality.

Exotic diseases are those that are introduced from a distant country. Many of these exotic, or introduced, diseases can be devastating; some have changed the makeup of entire forests. Some classic examples of exotic diseases affecting North American tree species are: white pine blister rust (*Cronartium ribicola*), chestnut blight (*Chryphonectria parasitica*), and Dutch elm disease (*Ophiostoma ulmi*) to name a few. Similarly, the pine wilt nematode (*Bursaphelenchus xylophilus*) introduced into Japan and other Asian countries in pine logs from North America is a serious problem in these and other countries on Asian *Pinus* spp. but is of little consequence to North American pines. In Hawai'i, *Acacia koa* appears to be very susceptible to root-knot nematode so the warm temperatures that characterize low elevations in Hawai'i can vastly favor the nematodes if present and can cause severe stunting, poor vigor, and mortality.

Exotic diseases of introduced species of trees are an entirely different issue. Severity can be variable from mild to very severe depending on factors such as environment, natural enemies, host vigor, strains for the pathogen.

Some examples of tree diseases in Hawai'i briefly discussed to illustrate the concepts of the *disease triangle* were: *Chryphonectria* canker (*C. cubensis*) on *Eucalyptus grandis* and *E. saligna*; *Botryospheria* canker (*B. dothidea*) and *Dothistroma* needle cast disease

(*D. pini*) on Monterrey pine (*Pinus radiata*) in Christmas tree plantations; the native mistletoes *Korthalsella complanata* and *K. remyana* on *A. koa* and *Metrosideros polymorpha*; the long term effect of planting *A. koa* over a hard pan about 12 inches below the soil surface; root-knot nematode (*Meloidogyne* sp.) on low elevation plantings of *A. koa* on former sugar cane land on Maui; and koa decline (*Fusarium oxysporum* f. sp. *koae* on Koa Ridge, Waiawa, and Tantalus on O'ahu.

Wood decay of the timber species grown in Hawai'i is an important problem. In 1963, Nelson and Wheeler found in a survey conducted from 1959-61 more than 50% of the large koa trees as unmerchantable due to excessive rot caused by a number of wood decay fungi. More work needs to be done to understand the current status of wood decay in both native and non-native trees grown in Hawai'i and how wood decay can be managed to minimize losses.

In summary, chemical sprays are not practical in most forestry situations because of the long growing cycle of trees. Therefore, forest/stand management utilizing the concepts of the disease triangle is necessary. A good knowledge of the tree species (or varieties, provenances, seed source) being planted; their environmental requirements (water, elevation/temperature, drainage, etc.); cultural practices (spacing, site preparation, thinning, etc.); and their key pests are important for their long-term growth and survival.

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Insect Pests of Tree Plantations in Hawai'i

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Introduction

Each year on average 15 new insects invade Hawai'i. The majority of new insects do not require control measures because they merely feed on Hawaii's plants without important damage. A few insects become pests and a management plan is needed to avoid economically damaging populations. Most serious insect pests are exotics that are not controlled by native insect-eating species in their new environment. This effect may be compounded when exotic tree species are planted because the trees are being grown in a habitat to which they are not adapted and the insects that attack them do so without competition from the insect fauna in the area of origin. Insect control measures in forests include insecticides, behavioral chemicals, biological control, and silviculture. Silvicultural control involves the creation of forests and forest environments that resist either the damaging pest or the effects of damage by them, and usually involves several kinds of control measures that are tailored to each specific biological situation (Smith et al. 1997).

One of the basic arguments in plantation forestry concerns the dogma that monocultures (pure stands) are highly susceptible to insect outbreaks compared with polycultures (mixed stands). Monocultures have a bad reputation, but perhaps are not as contrived as they first appear: natural monocultures are a common occurrence, for example, the domination by a single species in a climax forest. However, plantation monocultures differ from climax forests in that they are more even-aged and have reduced genetic diversity. Therefore, a host-specific insect has access to a virtually unlimited resource and an epidemic seems likely. The idea with polycultures

is that host-specific insects will have a more difficult time finding suitable trees "hiding" among unsuitable species or provenances. Despite the intuitive appeal and universality of the dogma, evidence for monocultures promoting pest outbreaks is hard to find. The observed problems with insect outbreaks in monocultures may be due less to the lack of genetic diversity and more with the lack of vigor (Speight & Wylie 2001).

Other classic generalizations about the damage caused by insects in forests are that vigorous fast growing trees are more resistant than slow growing trees, multi-cohort stands are more resistant than even-aged stands, and duplication of natural conditions will safeguard against problems. Although these generalizations are more often true than false, exceptions exist and we should keep an open mind when designing silvicultural systems, as each one will be unique.

With the wide range of commercial tree species being grown in Hawai'i it is impractical to list all the pests and possible countermeasures for each species. Table 1 provides a list of insects in Hawaiian forests that are considered important pests elsewhere in the tropics. I will discuss eucalyptus pests in some detail because eucalyptus dominates Hawaii's commercial plantings at present. Then I will discuss two polyphagous pests, black twig borer and Chinese rose beetle, that attack a wide range of commercial tree hosts, and discuss pest management approaches for these pests in Hawai'i.

Eucalyptus pests and the eucalyptus longhorned borer

Hawai'i's eucalypts appear to be free of serious insect pests at present. Eucalyptus foliage contains high concentrations of secondary compounds such as tannins, phenols and essential oils that have been shown in other insect-plant systems to provide protection from insect and fungus attack. Eucalypts have low nitrogen so defoliators must consume large amounts of foliage to get sufficient nitrogen for growth. Eucalypts have a remarkable capacity to recover from defoliation by insects or other causes by virtue of its system of bud protection: new shoots can be produced from naked buds in the leaf axils, from accessory buds at the base of naked buds, from epicormic buds at the old leaf axil, and from lignotubers (woody swellings that form at the base of the stem). In general, eucalypts are well defended against insect attack.

In temperate regions, the main pests of eucalyptus are accidentally introduced insects from Australia, whereas in tropical eucalypt plantations, important herbivores tend to be indigenous insects that adapt to eucalypts rather than exotic introductions. The major leaf eaters of eucalypts in their native range of Australia, Papua New Guinea, Philippines, and Indonesia are adult and larval beetles (families Chrysomelidae [leaf beetles], Scarabaeidae [scarab beetles], and Curculionidae [weevils]), stick insects (Phasmatidae), sawflies (Pergidae), and various moth and butterfly larvae (Limacodidae [slug caterpillars], Geometridae [inchworms], Nolidae, Anthelidae, Lasiocampidae [tent caterpillars], and Saturniidae [giant silkworm moths]) (Ohmart & Edwards 1991). Of these families of insects, only the beetle family Curculionidae and moth family Geometridae are represented in Hawai'i, which may partly explain the meager defoliator fauna on eucalypts here.

Many herbivores have adapted to feed on eucalypts grown as exotics in other areas. In tropical and subtropical regions, termites have been the most successful insects in adapting to eucalypts. Damage is mainly by foraging workers consuming lateral and tap roots of seedlings during the first year of planting, which places the establishment of plantations at risk. *Coptotermes formosanus*, the Formosan subterranean termite, is a pest of trees in Asia and is potentially a pest of eucalyptus and other forest trees in Hawai'i. *C. formosanus* is found

primarily below 1000' elevation, and is recorded to attack over 50 plants in urban areas around Hawai'i; it is relatively slow to disperse and is not known to be invading forests at this time. Other serious native defoliators include larvae of Geometridae and Noctuidae (loopers, cutworms, armyworms) in most countries where eucalypts are planted; arctiids (tiger moths) in South America; lasiocampids, psychids (bagworms), and saturniids in Africa; tortricids (fruit moths) and geometrids in India, grasshoppers and crickets in Italy, California, Africa, and Turkey; true bugs (Hemiptera) in several Pacific Islands; and ambrosia beetles (Scolytidae) in Argentina, Uruguay, Fiji, Western Samoa, and South Africa (Ohmart & Edwards 1991). Indigenous Hawaiian insects may adapt to eucalypts in the future as larger areas of plantations are established.

Approximately 20 species of Australian insect herbivores have become established in countries where eucalypts are grown as exotics, principally in New Zealand. The two most serious pests are *Phoracantha semipunctata* (Cerambycidae [wood boring beetles]) and *Gonipterus scutellatus* (Curculionidae). *G. scutellatus* has made eucalypt plantations nonviable in some areas of Africa, France and Italy, but has been controlled by an egg parasite in South Africa. This species does not yet occur in Hawai'i.

P. semipunctata, the eucalyptus longhorned borer, has been spread to all the major eucalypt growing regions of the world except India. In Hawai'i it occurs on Kaua'i, Maui, and O'ahu. In its native Australia, eucalyptus longhorned borer is a minor pest that attacks weakened or stressed trees, or newly felled trees, but in other areas it attacks young plantings. *P. semipunctata* damages trees by boring through the outer bark and along the cambium, and just a few larvae can kill a host by girdling the tree. Eucalypts vary in their susceptibility to *P. semipunctata* but even resistant species may become vulnerable to attack if grown on poor soils or under water stress. Studies have shown that *Eucalyptus globulus*, *E. grandis*, *E. saligna*, and to some extent *E. robusta* are all susceptible to this beetle when drought stressed (Hanks et al 1995), and consequently, the biggest economic impact of *P. semipunctata* is in areas where droughts are relatively common, such as Spain, Portugal and the Mediterranean region. IPM tactics mainly involve preventative silviculture. Stressful conditions should be reduced by avoiding moisture deficits, ensur-

ing irrigation, and avoiding damage by pruning. Selection of tolerant eucalyptus species will minimize attack. Sanitation will remove sources of adult beetles: infested wood should be burned, chipped, buried or kiln dried, and un-infested logs should be split or debarked. Biological control is generally not efficient at controlling eucalyptus longhorned borer because it spends most of its life concealed under bark.

Black twig borer

Black twig borer, *Xylosandrus compactus*, was first discovered on O'ahu in 1961 and has since spread to all the major Hawaiian Islands. It is one of the most serious insect pests of Hawaii's trees. It is known to attack over 100 species of plants in 46 families in Hawai'i (Hara & Beardsley 1979), and can be a serious pest of seedling trees including ironwood, *Acacia koa*, and eucalyptus, and others (Table 2). Female beetles bore into twigs making pin-size entry holes. Inside they excavate galleries and lay eggs. This excavation and the introduction of pathogens is the cause of damage to the tree. The larvae feed on ambrosia fungus (hence their common name ambrosia beetles) not on the wood. The "ambrosia" introduced to the tree by *X. compactus* for food is the pathogenic fungus *Fusarium solani*. Unlike other ambrosia beetles, *X. compactus* is able to attack trees in good vigor rather than stressed or dead trees. The damage is usually confined to twigs and seedlings up to about 1/2 inch in diameter. Leaves wilt and turn brown beyond the entry hole on the twig and branches turn brown and dry. Infestation levels can be high: in India infestation levels have reached 60-70% in young plantings of *Khaya* (Speight and Wylie 2001).

Pruning and destruction of beetle-infested twigs, branches, or trees is the first step in black twig borer management. Biological control by parasitoids is possible but a program of new introductions is unlikely because Hawai'i has 27 native scolytids that might suffer from non-target attack (Samuelson 1981). Silvicultural practices that promote tree vigor and health will help in resisting infestation or recovering from infestation. Insecticides (including botanicals) are used to control this insect in anthuriums, coffee, and orchids in Hawai'i and might be useful to protect high-value and nursery trees. Ethanol traps can be helpful to monitor for the presence of adult beetles.

Chinese rose beetle

Chinese rose beetle, *Ardoretus sinicus*, was first detected in Hawai'i in 1891 and had spread to all the major islands by 1898. Eggs are laid in the soil usually within an inch of the surface and take 10-14 d to hatch. New-born larvae burrow deeper into the soil to begin feeding. Larvae are commonly found in lawns and gardens but not in cultivated fields, so larvae probably feed on decaying plant material. The larval stages are completed in 2 to 3 months. Only the adult stage is above ground and damaging to trees. Adults feed at night, with the greatest feeding and mating activity in the first few hours after sunset. Chinese rose beetle is the consummate gourmand: Habek (1964) recorded 255 food plants representing 56 plant families fed upon by Chinese rose beetle adults and commented that it would be far easier to list those plants that the beetle does not attack. The adult beetle prefers to feed on mature foliage, a response to the high carbohydrate content of these leaves compared with young leaves, and the interveinal pattern of feeding (giving leaves a lace-like appearance) is distinctive.

While older trees can outgrow feeding damage, seedling trees may be severely stunted or killed if all their foliage is consumed. The simplest means to protect young trees from Chinese rose beetle is with a physical barrier, such as screen hoop cages. The beetle is a clumsy flier and will not fly up and into the open top of a hoop cage. Planting mixed species stands that include non-preferred trees will probably reduce damage because suitable tree hosts become hard to find. Surrounding susceptible trees with a hedgerow or stand of non-preferred trees may also interrupt host finding. Various botanical insecticides such as pyrethrins, neem, and rotenone may be effective, and various synthetic insecticides that are highly effective are available if needed.

Quarantine

Import restrictions and inspection is our main weapon against the introduction of new forest pests. USDA-APHIS stations Plant Protection and Quarantine officers at all the U.S. ports and in some foreign countries. All international passenger baggage, cargo, package mail, and conveyances are subject to inspection at these ports of entry. By monitoring pests and diseases in other countries, APHIS analyzes threats to U.S. agriculture and develops import restrictions on commodities based

on their risk of introducing harmful organisms. APHIS "pre-clears" some commodities before they leave their country of origin. Still, the introduction of unwanted alien species continues. A list of 10 unwanted foreign tree pests is given in Table 3; this list could easily be much longer. Most of Hawaii's new trees arrive as seed, which minimizes the chance for introduction of many foreign pests. Other sources of tree pests are scions and nursery stock; logs and sawn timber; and packaging crates, pallets, and dunnage. For example, the Asian longhorned beetle was recently introduced from China into the U.S. and is killing hardwood trees in New York City and Chicago. The beetle was introduced inadvertently in solid wood packing material. This pest would probably attack a wide variety of hardwoods in Hawai'i as well. APHIS restrictions are in place which require certification that shipments containing solid wood products and solid wood packing material (pallets, wooden boxes) have been fumigated at the site of origin. But new pests will continue to slip past inspection and interdiction efforts. For example, it is not surprising that a pest like the black twig borer arrived in Hawai'i: it attacks a wide range of hosts, its bore holes are minute and it can attack live plants, and one infested twig can contain the individuals needed to establish a new population.

Forestry is considered as a subset of general plant quarantine in Hawai'i, which tends to be more focused on agricultural considerations. The Hawai'i Forest Industry Association should work proactively with USDA-APHIS to identify pests elsewhere that may pose a threat to our forest resources should they be accidentally introduced. Information on foreign pests is available in the literature and on the web through regional and international quarantine bodies such as the International Plant Protection Organization (IPPO), Pacific Plant Protection Organization (PPPO), and European Plant Protection Organization (EPPO). The next step is to determine possible countries of origin, a host list for each pest, and potential modes of entry. To improve interception efforts at our ports of entry, diagnostic signs of infestation for the pest and a method of inspection can be determined. Early detection of a new invasion is difficult in forests compared with agricultural crops because of the

vastness and isolation of plantings, and the difficulty in inspection. And, unfortunately, experience tells us that our worst pests in the future are not even on the radar because they are non-pests in their native environment. Despite this, increased awareness of exotic pests will help us in developing ideas for combating pest types (rather than individual species) in our forests.

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Table 1. Insects in Hawaiian forests that are considered important pests elsewhere in the tropics.

Insect order and family	Scientific name	Principal host (genus)	Countries with	In Hawai'i ¹ reported damage
<u>Defoliators</u>				
Coleoptera (beetles)				
Curculionidae	<i>Myloccerus</i> spp.	<i>Acacia</i>	India, SE Asia	O
Scarabeidae	<i>Anomala</i> spp.	Many	China	O
Lepidoptera (moths)				
Noctuidae	<i>Spodoptera litura</i>	Many Australia, Oceania	India, SE Asia,	Outer islands ²
<u>Sap feeding</u>				
Hemiptera (true bugs)				
Adelgidae	<i>Pineus pini</i>	<i>Pinus</i>	Australia, Africa America	K, O, Mo, Ma, H
Coccidae	<i>Ceroplastes rubens</i>	<i>Acacia</i> , <i>Toona</i>	Africa, Australia India, SE Asia	K, O, Mo, Ma, H
Psuedococcidae	<i>Nipaecoccus</i> sp. <i>N. aurilanas</i>	<i>Dalbergia</i> <i>Casuarina</i>	Africa, India	K, O, Mo, Ma, H K
Psyllidae	<i>Heteropsylla cubana</i>	<i>Leucaena</i>	Pan-tropical	K, O, Mo, Ma, L, H
<u>Bark boring</u>				
Coleoptera (beetles)				
Bostrychidae	<i>Sinoxylon</i> spp.	<i>Acacia</i> , <i>Eucalyptus</i>	Africa, India SE Asia	O, Mo, Ma, H
Cerambycidae	<i>Phoracantha semipunctata</i> <i>Xystrocera globosa</i>	<i>Eucalyptus</i> <i>Acacia</i>	Africa, Australia America India, SE Asia Africa, America	O, Ma, H K, N, O, H
Scolytidae	<i>Xyleborus</i> spp.	Many	Pan-tropical	All islands
<u>Sap- and heartwood boring</u>				
Isoptera	<i>Coptotermes formosanus</i>	Many	U.S., China	K, O, Mo, Ma, L, H

Sources: Speight & Wylie 2001, Bishop Museum checklist of Hawaiian terrestrial arthropods

¹ K = Kaua'i, O = O'ahu, Mo = Moloka'i, Ma = Maui, L = Lāna'i, H = Hawai'i

² Kure, Midway, Pearl & Hermes

Table 2. Commercial tree hosts for black twig borer in Hawai'i.

Family	Scientific name	Common name
Anacardiaceae	<i>Mangifera indica</i>	mango
Araucariaceae	<i>Araucaria heterophylla</i>	Norfolk Island pine
Casuarinaceae	<i>Casuarina equisetifolia</i>	common ironwood
Leguminosae	<i>Acacia koa</i>	koa
	<i>Albizia lebbbeck</i>	siris tree
	<i>Leucaena leucocephala</i>	koa haole
	<i>Samanea saman</i>	monkeypod
Meliaceae	<i>Swietenia mahogani</i>	West Indian mahogany
	<i>Toona ciliata</i>	Australian red cedar
Myrtaceae	<i>Eucalyptus pilularis</i>	blackbutt eucalyptus
	<i>E. robusta</i>	swamp mahogany
	<i>E. sideroxylon</i>	red ironbark
Oleaceae	<i>Fraxinus uhdei</i>	tropical ash
Rutaceae	<i>Flindersia brayleyana</i>	Queensland maple
Sapindaceae	<i>Litchi chinensis</i>	lychee

Sources: Hara & Beardsley 1979, Samuelson 1981, Tenbrink & Hara

(<http://www.Extento.Hawaii.edu/kbase/crop/type/xylosand.htm>)

Other commercial tree genera that are black twig borer hosts: *Cassia*, *Cordia*, *Santalum*

Table 3. Ten most unwanted foreign insect pests for Hawaii's forest industry.

Insect species	Common name	Hosts	Countries
<i>Anoplophora glabripennis</i>	Asian longhorned beetle	hardwoods	China, U.S.
<i>Gonipterus scutellatus</i>	eucalyptus weevil	eucalyptus	Australia, Africa
<i>Hysiphyla grandella</i> & <i>H. robusta</i>	shoot borers	<i>Toona</i> , <i>Swietenia</i> , <i>Khaya</i>	Pantropical
<i>Hyblaea puera</i>	teak defoliator	teak	India, SE Asia
<i>Helopeltis</i> spp.	mirid bugs	<i>Acacia</i> , eucalyptus	India, SE Asia
<i>Indarbela quadrinotata</i>	bark-eating caterpillar	teak, mahogany, <i>Acacia</i> , <i>Casuarina</i>	India, SE Asia
<i>Neotermes tectonae</i>	termite	teak	Indonesia
<i>Perga affinis</i>	steelblue sawfly	eucalyptus	Australia
<i>Thyrinteina arnobia</i>	(geometrid)	eucalyptus	Brazil

Source: extracted from Speight & Wylie 2001

Weed Control for Hawaiian Forests

Dr. Joe DeFrank, Dept. of Tropical Plant and Soil Science, UH Mānoa CTAHR

Weed control in Hawai'i can be viewed from two different perspectives. The conventional view is to start with a weed- and plant-free planting site and maintain a monoculture of planted trees with herbicides. Although this approach can provide for maximum growth of the tree crop it also exposes the forest to erosion from wind and rain. In this presentation I will discuss an alternative approach to vegetation management that involves the establishment of ground cover before the forest trees are planted.

Hawai'i foresters are handicapped with regards to the number of herbicides that can be legally used to control weeds. The majority of herbicides with forest sites listed on the label are for temperate forest species such as loblolly, slash and Virginia pine. Few of these species are grown in Hawaiian forests, where broadleaf hardwood species are most common. Herbicide use in Hawaiian forests can be broken down into three separate categories: broadcast pre-plant, post-planting pre-emergence, and post-planting post-emergence. Since most new forests in Hawai'i are established in former agricultural fields that have been abandoned for 5-10 years there is a large and viable seed bank of weeds to deal with in practically all areas of the state.

The best way to reduce the weed seed bank in the soil is to clear the existing vegetation and prepare the site for safe movement of tractors with hydraulic sprayers. Once the site is cleared of vegetation, the natural instinct is to plant trees as soon as possible to start the productive phase of the forest cycle. This is a huge mistake with regards to weed control. The first thing to do after land clearing is to prepare to make a broadcast application of contact herbicides across the entire forest planting site.

Weeds should be allowed to germinate and grow to the 4-6 inch stage or to the point where weeds just start to overlap each other. Two systemic contact herbicides are labeled for forest site preparation in Hawai'i: Accord® (glyphosate, Monsanto) and Garlon 4® (triclopyr, Dow AgroScience). Accord® contains glyphosate, a common herbicide used to kill both grass and broadleaf weeds. Garlon 4® is a more specialized material that works best on broadleaf weeds, especially legumes. A mixture of both of these herbicides will insure a wide spectrum of weed kill without residual effects in the soil.

Weeds should be treated at least twice before the first tree is ever planted. Weed seed germination can be maximized by applying fertilizers. Tree planting can begin when a complete kill of germinated weeds is achieved. Trees should be planted while minimizing the amount of fresh soil, containing viable seed, brought to the soil surface. After planting, herbicides can be applied that kill weed seedlings as they germinate and grow through the treated zone of soil. Pendulum® (pendimethalin, BASF) can be obtained in either a granular (G) or water dispersible granular formulation (WDG). The WDG formulation is dissolved in water and sprayed. The granular formulation can be applied with a fertilizer spreader. Both forms can be applied at planting, however, application should avoid getting the chemical into planting slits so that tree roots are not directly contacted by the herbicide. Goal 2X® (oxyfluorfen, Dow AgroSciences) is another preemergence herbicide is available to Hawaiian foresters but is only labeled for three eucalyptus species (*E. viminalis*, *E. pulverulenta* and *E. camaldulensis*). Goal® applications should minimize contact to tree foliage to minimize contact injury.

After trees are planted there are few options for chemical control of emerged weeds. Small grasses can be safely killed with Fusilade DX® (fluzifop, Zeneca). Fusilade® only kills grasses and has little to no effect on any broadleaf plants. Good coverage is required to make Fusilade work properly; sprays are rainfast in 45 minutes. Accord® can also be used as a directed spray to kill both grass and broadleaf weeds. Spray applications must avoid contact with desired plants to prevent severe injury or death. Once the forest canopy grows and shade the between row space, weed control is a greatly reduced issue for most growers.

Maintaining a weed-free forest planting cannot be viewed as an ecological sound method of forest establishment. In areas that receive heavy rainfall, a great deal of valuable topsoil can be lost forever from unprotected fields. Successful use of ground covers, like successful weed control, must begin before the first tree is planted. Growers can plant direct-seeded ground covers if they know the species they select will be quick to establish, non-invasive and easy to manage around the base of the planted forest species. Weeds can also serve as good ground covers if they are managed properly before the crop is planted.

As described earlier, Fusilade DX® is a selective herbicide that controls most grassy weeds and is safe when broadleaf crops are contacted. This feature makes Fusilade DX® an ideal tool for managing grassy ground covers in tropical hardwood forests. Finding the right seeded ground cover requires extensive testing to find the right species and then using the proper equipment to accurately plant seeds. An alternative to seeding of groundcovers is to use naturalized grass weeds to serve as forest ground covers. Conditioning this wild collection of plants is key to making this approach work in newly planted hardwood forests.

Site preparation is the first element of successful ground cover management in all tree crops. The site should be graded to allow for safe tractor movement to include both herbicide spraying and mowing. Once the site is graded, fertilizers are applied to enhance weed growth. Garlon 4® can be applied to the weedy mixture of plants to remove most of the broadleaf weeds and leave only the grassy species. Crop rows are marked with stakes and Accord® applied to establish a weed-free strip. As the grasses grow in the between row space they are mowed and clippings directed to future rows of forest trees. This process continues until a thick layer of mulch is produced in the planting rows. Fertilization of the grass areas is important to maximize the amount of biomass produced that serves as weed suppressing agent in the crop row.

Forest trees are planted into weed free rows that are heavily mulched. After planting, the grassy areas can be chemically suppressed with applications of Fusilade DX®, using sub-lethal rates. When the trees get big enough, mowed clipping can be directed to the crop rows again. With only grasses to deal with in the newly established plantation, Fusilade DX® can provide a safe and effective means of recovering plants that may be overrun by aggressive plants.

Planning is the key element to successful weed management in newly planted forests. Weather and unforeseen delays can often result in plantings lost to aggressive weed growth. A management strategy that makes use of a variety of biological and chemical tools has the best chance of producing the desired result, healthy trees and a biologically stable soil surface.

Editor's note: For more information on weed control, see CTAHR weed control publications available free online at <http://www.ctahr.hawaii.edu/freepubs> or from Cooperative Extension offices. While few herbicides are specifically labeled for tropical timber species, some are labeled for forestry in general, or silviculture, or tree plantations, or tree farms. Users must read the label on the herbicide package and follow directions carefully.

Hawai'i Forestry and Property Tax, A Comparison by County

Bill Eger

Editor's Note: The following is an abridged version of the talk presented at the symposium. Readers interested in the full version are encouraged to contact Mr. Eger directly.

Tax policies are subject to revision, and property tax rules on Kaua'i have been revised since the presentation was given in June 2001. Landowners are encouraged to work with their county property tax offices to get up-to-date information on property tax rules.

Before 1978 the State of Hawai'i had full responsibility for property tax assessments and collection in all four counties. Each county provided the state with the amount of revenue required for their operations and a tax rate was established to provide the funds for each county from its total assessed values.

With a growing public desire for home rule, county government support statewide and willingness by the state, counties were given the responsibility of their own property tax assessments and collections. The 1978 Constitutional Convention submitted an amendment that was passed in the election November 7. After a legally imposed two-year period for transition the counties assumed full management of all property taxation.

This is a good time to be reminded that – at 42 years of age – we are a relatively new state. It is generally acknowledged that Hawai'i took the fundamental principles of the Constitution of Alaska – another new state – to form our state's basic legal document. That is the primary reason the states of Alaska and Hawai'i have the most powerful governors and weakest Legislatures in the nation. Alaska, by the way, retains assessment of

property taxes as a state function. The governor may not always be right but he is always *The Governor!*

Moving property taxation to the counties was not a runaway winner in Hawai'i. The final measure passed the Constitutional Convention – with a number of compromise amendments – by a vote of 65 to 35 while another dozen delegates were out of the room for some reason. The debate was instructive. Those wishing to retain the function as a state responsibility were concerned that dividing the job among the counties would run up the cost of the process. They were right. The state property tax office on the Big Island in 1978 had 17 employees compared to 42 today. Delegates speculated that the cost – to be borne by taxpayers, of course – would go up by perhaps \$200,000 to \$400,000. In fact the Big Island's cost for 2002 is budgeted at nearly \$3 million. One delegate noted that the committee hearing the issue had only the county government representatives speaking in favor.

Delegates in favor stressed that counties – which rely on property taxes for 80 percent and more of revenue – should be in charge of that important tax.

A more serious policy concern was advanced in the debate over uniformity of tax policy throughout the state. This was the greatest compromise in the final document but the proceedings of the meeting aren't clear on an important point.

The enabling provision in the Constitution – Article 18, Section 6 – clearly required an eleven-year pause before changes could be made in exemptions and deductions by ordinance without prior agreement by three of

the four counties. That agreement had to be that a change was required and resulting similar legislation was to be passed by the four counties, preserving uniformity. There is little in the debates, as recorded in the two-volume Proceedings, to show the sentiment for permanent uniformity requirements after the clearly imposed period. One problem may have been that the neighbor islands could impose changes with their three votes against Oahu's one.

Enabling law, Hawai'i Revised Statutes 246A-2, and Section 6 of the Constitution can be read today to continue the requirement that changes in those two vital property tax matters – exemptions and dedications – can only be made with support of a majority of counties and must all be uniform.

A Big Island Deputy Corporation Counsel, whom I respect, disagrees, holding that the HRS section – though still in effect in the written code – no longer applies. Honest men disagree, as you know, but if the existing law does not have a clear sunset provision it is still there. The intent to retain uniformity of assessment policies relating to exemptions and dedications throughout the state is a good goal.

Uniformity of policy among the counties regarding assessment policies for taxation purposes no longer exists and the most affected industry is forestry. State law on property taxation in 1978 did not make reference to forestry, a lack that continues today in two counties, Maui and O'ahu. Where forests of any kind exist on those islands – tree farms or native forests in open space – they are treated as agriculture with slight differences in policy and rules on Maui and O'ahu. As far as I could determine neither county has tree farms but both do enjoy extensive natural forest stands, some rich in indigenous species.

Kaua'i and Hawai'i counties have far more extensive use of tree farms. Kauai's tax ordinance allows full exemption from property taxation for tree farms, zero taxes during cultivation and no *ad valorem* taxes at harvest.

There is no explicit tree farm provision in Chapter 19, Hawai'i County's tax code, but a rate is set by the same rule affecting all crops as one of the several types of agriculture practiced on the island. The fixed assessed value for tree farms was reduced recently from \$1,000

to \$500 per acre, a figure that drops to \$250 per acre upon 20-year dedication.

There is wide divergence of assessment practices among the counties of Hawai'i. The impact on forestry – where there is much more divergence than on any other tax subject – is unmeasured. Maui offers the most favorable tax rate on all open space in private ownership. With some exceptions possible, such space is assessed at \$60 per parcel per year regardless of actual sales value. That rate applies regardless of the size of the parcel, whether ten or a thousand acres. The assessed value is set for food crops, ranching, forestry wherever it exists and fallow land vacant and beautiful but not in cultivation.

At least two large Maui ranches are in the process of major reforestation on extensive pasture ranges using native species. Some see danger in long-term investment where the county could have a change of heart about the very low tax valuation during the twenty to thirty years required for a forest stand to mature. A dedication provision would help reduce that fear with the hope of a stable per acre value guaranteed for the growth period required.

Hawai'i County, alone, offers native forest dedication that must by law enjoy the lowest tax classification available, currently pasture land. One motive for this fairly new law was to provide ranchers an alternative to clearing land of existing forests in order to qualify for low pasture rates. Because dedication is possible for 20 years on the Big Island, it is a safe investment for either native species retention or the creation or improvement of new indigenous forests. Here is what the law says:

“For purposes of taxation, a native forest shall be defined as a parcel with a minimum area of ten acres or a group of adjoining parcels with total acreage of any amount and which has a forest cover of 60 percent or more which shall be composed in the majority of indigenous plants as defined by the Department of Land and Natural Resources Division of Forestry and Wildlife (the Division). Not all parcels within a group of parcels must meet the cover requirements but the total area covered and dedicated must meet the requirement.”

“For purposes of dedication parcels or groups of parcels narrowly failing to meet the requirement for cover or indigenous plants may be recognized as native for-

ests if the application is accompanied by a management plan which specifies annual improvement schedules to replace non-indigenous species with plants recommended by the Division for the area or to plant indigenous plants on bare land to bring the parcel or group of parcels up to the required definition within a five-year period. The Division must approve the management plan. Progress on the management plan shall be monitored annually by the Division until its goals are met and the native forest area is fully recognized. On agreement by the Division certified arborists may be used for both recognition and monitoring purposes."

In the law – without DLNR's advance approval – DOFAW has the burden of defining native forest, though the Division would like to be spared the honor. DOFAW is already overburdened but there is no other agency with expertise and the necessary authority to decide. We attempted last year to seek a useful definition of native forest that would serve to help county tax agencies just as they are presently getting help on the HRS definition of tree farms. The effort for a native forest definition was not successful but Tim Johns promised it would be brought up in the 2001 session, an effort that was thwarted when he resigned to join Damon Estate Trust. We'll try again next year, perhaps.

Before closing, let's spend a few minutes on the mechanics of property taxes.

No law can be sufficiently comprehensive to cover every detail of each land situation. Every county has more or fewer rules to answer inevitable questions on details. These rules deal with the amount of assessment to be placed on the different uses of agricultural land, for example. Rules are much easier to change than having rates set by a county council. That rings an alarm bell because it's harder to get copies of these rules and, though they can only be changed with a preceding public hearing, they are subject to abuse by tax departments seeking ways to increase revenue. They are also not given the care in language available for ordinances passed by the county councils, providing more room for different interpretations.

On that point, once a tax ordinance is in place it becomes very difficult to change. A substantial review of the Big Island's Chapter 19 took most of two years of

committee work to revise, mainly for clarity. That effort was vetoed because one of the clarifying efforts created a section that might have allowed a hotel to be classified as a much lower tax value if the resident manager lived there full time, or so the mayor at the time maintained.

The most substantial way to make significant change in law or rule is through a written, formal opinion by the county's corporation counsel. You may think you know what the word "cultivation" means but in tax discussions it needs an explanation. There are too few farmers in the halls of our legislature or in tax administration so that simple word takes on complexities in the real world. For years the Big Island's Property Tax Division defined "cultivation" as "plants in the ground." Every person who has practiced agriculture, large scale or small, knows that farm projects start with planning, long before you have sprouts showing. With an acre or two at stake, the issue was not sufficiently significant to get a formal opinion but with 16,000 acres – a tree farm – it became crucial. Two issues were taken to the Corporation Counsel: 1. What stage of agricultural activity begins cultivation, and 2. Shouldn't a lease for a single purpose – agriculture – qualify the entire leased land to be classified as agriculture with or without plants?

Both rulings favored farmers and I presume they remain in use today. Cultivation begins as early as acquisition of the land for a farm use. It can be demonstrated by plans for what will be planted where, loan documents and a lease with the single purpose of agriculture.

There are many very small points in taxation that can spell the difference in success and failure of a commercial enterprise. That includes forestry.

The forestry industry – especially that sector on tree farming – needs to closely study the effects of the diverse range of assessment practices. There is no case law on the point but we do need to determine in court if the county-by-county policy now occurring is in accord with the state's constitution and the section of public state law that is on the books. Second, we need to learn if varying policies in different counties serve the needs of both forestry and the general public. One result could be very harmful competition between the counties for forestry, an industry that requires long-term and consistent tax law.

After a lifetime in public affairs, it is my belief that any industry without a clear framework of needed legislation covering a broad spectrum of requirements is a sitting duck. Packages of helpful legislation in effect in other states are the usual source for the raw materials of efforts to present a legal bulwark to every level of county, state and federal government.

If those of us who believe in forestry, know about its benefits and want to insure healthy and productive forests throughout Hawai'i don't write these laws, who will? Education of lawmakers at all levels should be undertaken to familiarize them with forestry's needs and the benefits available for the economy and our lifestyle if those needs are met. It is a complicated subject that requires sophisticated understanding.

This is not a one-year project but, rather, a continuing and organic project that will take a long time to be fully productive. But what is the alternative?

Similar efforts should go to news media that will then be able to understand the legislation sought and the benefits to be derived.

We need to get the leaders of our state and counties out into the woods. We need to make them comfortable with those lands that I'm sure everyone in this room agrees are the most beautiful and soul-satisfying places on the Hawaiian Islands. These are the forests that make our islands habitable with rain that would not fall without them.

Most important, trees won't live without care. That is especially true in the tropics where invasive species are now at work killing broad forest expanses. Caring for the forests is expensive but, fortunately, selective harvesting, necessary to maintain forest health, provides the revenue for the upkeep. More citizens need to learn that from those of us who truly love and understand forests and the care so necessary to their continued health and existence.

A view of taxes from the assessment side; A comment from a county assessor

Because of the high values on some of the north shore properties, some people have decided that they are now farmers or tree farmers. The economic consequences are far greater here on Kaua'i than on the east side of the Big Island. The official county position is one of wanting to support diversified agriculture, tree farming and other uses of the land. If property is put into agricultural use as part of a real agricultural endeavor, all is well, but when people use the agricultural use laws to minimize their tax liability the tax burden is shifted to the other classes. It has been a long standing practice to give tax relief to legitimate farmers who are providing the food for the community and jobs. The Property Tax department is looking to reach a balance among the parties, the tree farmer, the farmer, the other taxpayers, the council and the administration.

Let's face facts: no one says "Let's go to the north shore of Kaua'i, pay a million dollars for five acres, and grow trees." It is not economically feasible! Yet when these same people get their first tax bill they want to become farmers. Legitimate foresters and tree farmers want to protect their favored tax status and are helping to write the law such that there will not be abuses.

We cannot forget that if we give one person a break, another person must pay the bill. The question is "What do we value as a society and who is going to pay for those values?"

Protecting Tree Plantations from Fire

Bryon Stevens
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J. B. Friday
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Introduction and a Disclaimer

Every site is different. Threat of fire varies greatly among different sites. It is up to you, the individual landowner, to evaluate the risk from fire for your tree farm. Your insurance, your bank, any incentive programs you might participate in, and environmental review processes might all call for some sort of fire plan. It is better to be safe than sorry: plan now for the worst and worry less later.

Why Worry About Fire in Hawai'i?

Statewide there were 659 "wildland" fires reported between 1996 and 2000. Over sixty thousand acres burned and resources valued at \$85 million were lost. Most fires were in "brush" and untended forest areas; no figures were available for privately owned tree plantations. Some tree farmers believe that their trees live where it's too wet. However, any tree farm needs a fire management plan. Good sites for trees also promote fast growth of grass and brush, especially before canopy closure. Drought and high winds can happen at any time during the year, even in areas that are generally wet, and high elevation and leeward sites are often subject to low humidity.

Prevention, pre-suppression, and suppression

Prevention means not letting fires start in the first place! Common ignition sources include:

- Power tools
- Mowers
- Catalytic converters, especially on vehicles driven through tall, dry grass

- Heavy equipment
- Welding equipment
- People smoking cigarettes
- Missing spark arrestors on machinery and small engines

Certain times are high risk for wild fires. Keep track of the weather, wind, and rainfall on your farm. Close areas if it's so dry that there is a risk of fire. If a fire does start, catch it before it gets away. Have the following available or accessible on-site, if possible:

- Fire extinguishers, water pumps
- Water: tanks, holding ponds, reservoirs
- Fire tools: shovel, fire rake, axe, pulaski
- Phone on site to call the fire department
- Keys to the bulldozer

The Wildland-Urban interface, or life on the plantation

Many rural landowners live in the midst of tree plantations, now that houses are becoming interspersed in agricultural and forest land, rather than concentrated in plantation camps. Trees on plantations and tree farms need to be protected from house fires, and houses need to be protected from wildfires in the forest area. Homeowners should keep a 30-foot wide buffer free of burnable material around the house and not let dead brush and litter pile up near the house. Even though you may take care not to let fires start on your own property, you still need to be concerned with fires from roadside starts, arson, careless neighbors, or wildfires in the neighborhood.

Fuels

Pre-suppression of fires involves planning ahead about fuels, access, and water. The “fire triangle” is fuel, oxygen, and heat (figure 1). Without all three, you don’t have fire. The “fire *behavior* triangle” is fuel, topography, and weather. Fuel is the only component that you can really control. Availability to burn and fire behavior depend on moisture, loading, arrangement, continuity, and size. Live trees aren’t fuel; dead vegetation on the ground is. Fuel moisture is critical. Fine, dead material such as dry grass carries fire. Fuel conditions can change rapidly; a few dry, windy days can dry out vegetation to the point where it may burn. Fuel arrangement is also critical. More available oxygen makes a hotter burn, so standing dead or dry vegetation is more likely to burn and likely to burn hotter if it does catch fire than matted-down vegetation. Heavy fuels such as dead wood burn longer and hotter than light fuels such as grass and ferns. Hotter fires may damage the bases of trees or kill them by girdling them, whereas many trees can survive grass fires. Hotter fires are also harder to put out. Slash piled or windrowed during site preparation operations may pose a fire risk, as may chip mounds. Fires also need continuous fuels to spread, and breaking fuel continuity can help prevent fires from spreading. “Ladder fuels” reach from the forest floor up into the canopy, and include broken branches hanging down and tall grass that reaches the tree canopy. Ground fires can spread up ladder fuels and become canopy fires, so these should be removed where possible. Tree canopies are not likely to burn unless supported by surface fire. Ground fires spread as the fire heats up the grass or litter ahead of it and allows the fire to burn with increased intensity. Remember that the plantation is more than just trees, and you need to manage all the vegetation on your tree farm. Select for less fire-prone understory plants, such as ferns or short grasses.

Breaks

If you can’t keep the fuel under control, then you need breaks. Fire breaks are meant to stop fires completely, whether they’re still ground fires or crown fires. Fuel breaks are where the fuel is modified so that the fire intensity or rate of spread is reduced, possibly so that the fire can be suppressed at that point. Mowed grass may serve as a fuel break, as a fire would spread slower through mowed grass than through tall grass. A quick

rule of thumb is that fire breaks need to be two times the fuel height. Breaks should be located around the perimeter of the plantation and between compartments. Build your breaks into your harvest plan, as the same roads you will be using to access your stands for thinning or harvest will also serve as fire breaks. Remember that fires are wind-driven, so locate breaks perpendicular to the prevailing winds. Locate breaks on the lee sides of ridges, so that they will be able to stop the smaller fires as they creep down the ridges (figure 2).

Access

If the worst happens and you do have a fire, firefighters do need to be able to get access to your land. If you don’t live on your property, have a contact address or at least phone number posted. Signs should be made of metal so that they don’t burn during a fire, reflective so that they’re visible at night, and not be covered by brush or weeds. Better yet, make sure the county fire department has a map of the location and layout of your property and contact information for you. Make sure they can get their truck through any gates. While fire trucks carry bolt cutters which they will use in an emergency, gates with openings less than 12 feet wide may hinder access. Likewise, plan roads that are wide enough and will allow fire trucks access. Keep roads in good condition. Make sure that any bridges are wide enough and can bear enough weight. Provide for vehicle turn-outs and safety zones. Designing a good road system should be part of your overall management plan, and when you’re planning for your harvest you also should be thinking about fire access.

Water

There are many water sources available on tree farms, including:

- Hydrants
- Ditches
- Reservoirs
- Natural bodies
- Water tanks
- Fold-a-tanks
- Tank trucks

Water is no help if the firefighters can’t get to it, so make sure that the water is available. Make sure pipes have standard threads. If a stream or ditch is your water source, you may need to deepen it at strategic points enough so

that fire trucks can access them. Harden an edge of any reservoir so that trucks can drive up to it, or install a standpipe. Find out if helicopters will be used in fighting fires and how you can create helicopter dip access.

Fire suppression

Fire suppression in private tree farms in Hawai'i will almost always be done by the county Fire Departments. Their priorities, however, are protecting lives and structures rather than agricultural or forest crops. Moreover, their experience with wildfires varies. If it's a big fire, suppression will likely involve several agencies, including the Counties, the State, and Federal agencies. The role of the state Division of Forestry and Wildlife is to protect state lands and protect watersheds.

Fire fighting tactics

Fire fighting itself is a big topic and beyond the scope of this presentation, but knowing how firefighters work will help in planning for fire prevention. The first line of defense is a direct attack on a small fire. A rapid response time is key to success here. For larger fires, firefighters create a fire line with bulldozers or by hand to try to contain the fire. They then fight fire with fire by setting backing fires which burn towards the main fire. Backfires create a burned area ahead of the fire, stop-

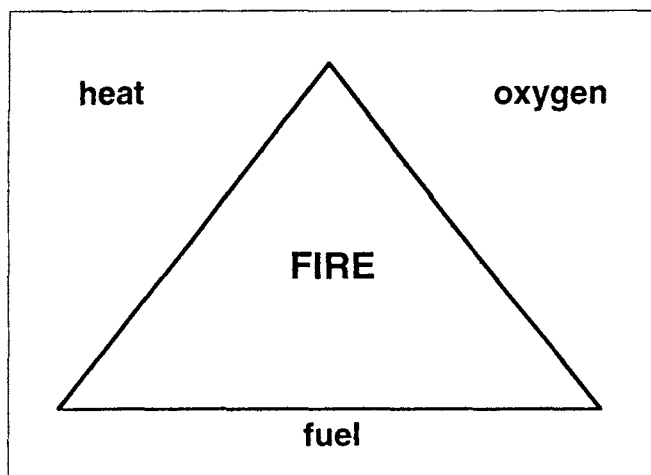


Figure 1. The fire triangle.

ping its spread. Backing fires are less intense than head fires and work because the heat of the main fire creates an updraft and draws air towards it.

Take Home Points

- Mow your grass
- Plan for the worst
- Make friends with the Fire Department



Figure 2. Fires are wind-driven. Place breaks on leeward sides of ridges.

Using Forest Plantations to Mitigate Global Warming Through Carbon Sequestration

Lionel Kutner, TREES FOR LIFE

Background

There is a small 'early market' for carbon credits, which has functioned on the basis of individual contracts between willing buyers and sellers over the past ten years.

This market precedes the existence of a formal exchange mechanism for carbon credits and of internationally agreed rules for offsetting carbon dioxide emissions in forest projects. The United Nations Framework Convention on Climate Change has not completed its process and may not result in U.S. ratification of the treaty agreements (known widely as the Kyoto Protocol). Yet market based mechanisms discussed at its meeting in Bonn, July 2001 largely adhere to the rules as developed so far.

One hundred recent trades by 650 companies reporting carbon trades under 1605b of the UNFCCC resulted in 45 million tonnes of carbon dioxide credits purchased by private industry in 2000. A further 35 million metric tonnes were bought by governments, for a total of 80 million tonnes that year. Prices ranged from \$1 to \$10 / metric tonne. While most trades have been at a modest scale at this experimental stage, the estimated value of the year 2000 market in carbon credits was \$120 million.

Producing a Carbon Credit

A "CERC" Certified Emissions Reduction Credit is created after actuarial loss review plus international quality assurance by third parties (Price Waterhouse Coopers), and marketed internationally (Cantor Fitzgerald)

A ten-step sequence involved in establishing an authenticated, verified, saleable carbon credit for a forestry project was presented.

- 1 Determine management change
- 2 Commit to duration of project / time frame for agreement
- 3 Establish baseline total site carbon measurement (post 1990 or current)
 - Take carbon inventory of existing vegetation, use various growth/yield models and project total site carbon, under current management over that given time frame
 - Include: living vegetation, trunk, branches, roots, understory, dead organic matter above + below ground, soil microorganisms, mineralized carbon - all taken together.
- 4 Create detailed plan, noting all changes in management of the given site
- 5 Estimate net increase in carbon sequestered / stored
 - use same model/time frames as baseline, include end product
- 6 Verify
 - Third party reviews all modeling and accuracy of calculations, also called "authentication"
- 7 Monitor program
 - Third party reviews, on a schedule established at authentication, for life of CERC
- 8 Plan insurance
 - Third party provides project, can be reserve CERCs (extra plantings)
- 9 Register credits
 - Third party Unique code number prevents duplication, or misrepresentation, facilitates tracking

10 Create easement

- Carbon rights transferred/sold are likely to be a lien on deed

Hawaii's Potential

Properly marketed, the paper contended Hawaii's could be the crown jewels of all carbon credits, considering the value to a purchaser of also supporting several environmental and societal benefits

- Endangered species preservation
- Rainforest re-creation
- Watershed protection
- Sustainable economic development for rural communities
- Cultural assistance to indigenous peoples and the reliability of a Hawai'i credit
- Stability; location within the US

Hawai'i Pilot Carbon Credit Sale

The paper briefly referred to four landowners on the Big Island of Hawai'i who have partnered to prepare a pilot sale of Hawai'i carbon credits.

They were taking a proactive approach, aiming to make the process fit the land vs. trying to make the land fit the process; and aiming to position Hawai'i to best take advantage of its possibilities, before some broker/entrepreneur takes advantage of Hawai'i landowners.

This first exploration of the market included 40,000+ acres, mainly of newly forested land and earliest calculations suggested 12 million metric tonnes of carbon dioxide would be sequestered in these projects, with an anticipated 2002 market value approaching \$40,000,000.

TREES FOR LIFE, acting as the project manager, facilitates the Hawai'i pilot and is available to discuss their process thus far. Contact: Lionel Kutner (see Speaker Contacts section, this volume.)

Selecting Non-Invasive Species for Forestry in Hawai'i

Duane Nelson, Forest Health Coordinator
USDA- Forest Service, Institute of Pacific Island Forestry

Invasive alien plants pose one of the major threats to Hawai'i's biodiversity. Unfortunately some of these species were established as intentional introductions for reforestation, windbreaks, landscaping or watershed protection. Some unfortunate introductions include melochia (*Melochia umbellata*), silk oak (*Grevillia robusta*), Faya tree (*Myrica faya*), black wattle (*Acacia mearnsii*), blackwood acacia (*Acacia melanoxylon*), Mexican weeping pine (*Pinus patula*), ironwood (*Casaurina equisetifolia*) and miconia (*Miconia calvenscens*). Though these species may provide some benefits, they have unarguably become weeds that impose huge costs to landowners, and society.

Exotic tree species have become the foundation for Hawaii's developing forestry industry and have played a key role in reforestation efforts since the early 1900's. Despite growing interest in koa and other native species, ease of establishment, rapid growth, high stumpage value, disease resistance, novelty and suitability for plantation forestry continue to entice foresters to plant exotic species for many commercial purposes.

Some of the species of choice also present risks of spreading beyond plantations into native forests or surrounding agricultural and domestic areas. If we could predict the behavior of a tree prior to introduction or wide-spread use, then we could select against weedy species and use more benign species to achieve similar objectives. The intent is not to denigrate decisions made by our forestry forbearers, but to help avoid bad decisions now and in the future. Also, where harsh sites and conditions may dictate the use of particularly hardy species for watershed and soil protection (e.g. *Tamarix* spp. for restoration work on Kaho'olawe), we could use these

tools to evaluate risks vs. benefits and plan for mitigation.

In about 1996 the number of introduced plants in Hawai'i exceeded the total number of native and endemic species. Many of these introductions have been positive, contributing to agriculture, forestry or adding to the natural beauty of the islands. Many other species have had essentially no impact. However, history has shown that about 10 to 12 percent of these introductions become invasive weeds that impact ecosystems, the economy or human well-being. Similar trends are occurring on many Pacific islands.

Executive order 13112, signed by President Clinton in February, 1999, defines an alien species as "any species (including its propagules) that is not native to that ecosystem."

The Executive order further defines an invasive species as "An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Cronk and Fuller (1995) emphasize biodiversity and ecosystem function, defining invasive species as "species that displace natives or bring about changes in species composition, community structure or ecosystem function."

Table 1- Impacts of Invasive Species

- They are one of the greatest threats to biodiversity in Hawai'i
- Many have totally altered ecosystem structure and function
- Recall is not often possible and control may be difficult

- Many have caused enormous economic damage
- Some are a threat to human health
- The problem will get worse with time.

Many studies have tried to determine what makes a species invasive. Unfortunately no single answer is obvious. However the best single predictor is whether a species is invasive elsewhere with a similar climate (Panetta 1993, Reichard and Hamilton 1997).

Some other characteristics contributing to invasiveness include:

High fecundity- Plants that mature quickly and produce many seeds per plant each year are far more likely to spread quickly than those plants producing fewer large seeds.

Rapid growth rate- Plants that germinate and grow quickly can quickly occupy areas, overtop native species and exclude other plants.

Animal or wind dispersed- Animals (including humans) and wind can rapidly spread propagules long distances and can circumvent natural barriers to dispersal (e.g. oceans, mountains, deserts) allowing rapid invasion of or new ecosystems. A special case of animal dispersal is intentional spread by humans. Economic or esthetic considerations often entice humans to spread plants into novel areas. Species with desirable characteristic for forestry, for example may be moved long distances, to be introduced over large areas in remote locations.

Large initial or repeated introductions- A species is more likely to become established if many individuals are established at once or if they are introduced repeatedly. Introductions of many individuals may help ensure genetic diversity, larger seed pools increasing the chance that seed will find suitable sites, and increased chance of survival of localized catastrophic conditions. Repeated introductions increase total population size and replace individuals lost to mortality.

Climate conditions similar to the home range- and tolerance of variable conditions would ensure pre-adaptation of the species to its new locale. Tolerance of a wide range of environmental conditions allows an invasive to succeed over broad areas and may give it a com-

petitive edge over native species. For example, *Miconia calvescens* grows best in full light, but also germinates and grows well in shade, allowing it to be one of the few species that can reproduce under its own dense canopy.

Tolerance of disturbance- allows plants to quickly occupy gaps.

Forestry planting of potentially invasive species may be unusually risky for several reasons. Trees are often planted over large areas at higher elevations, in close proximity to more pristine native forests where plants could readily naturalize and spread into native forests. Plantations and surrounding forests may not be closely monitored for naturalizing plants for extended times, therefore new invasions may not be readily detected. Also, foresters may introduce new species far from previous introductions contributing to rapid range expansion of novel species.

Unlike most agricultural crops, forestry trees are not so highly bred that they have become reliant on cultivation for survival. Hence most species are still very fit for survival in the wild. Nitrogen fixing trees (e.g. *faya tree*) enhance soil nutrients, facilitating invasion by other species and perhaps shifting long term ecosystem development. Perhaps of greatest consequence is that forestry trees are large and are capable of overtopping native trees and dominating habitats.

In most cases there is a delay between the introduction of a species to a new environment and the recognition of invasiveness, known as "lag phase." Though the reasons are not fully understood, the phenomenon has been attributed to many possible causes including minimum population thresholds, release from predation, presence/absence of pollinators, local or global climate change, and many others. Regardless of the cause, a lag between initial establishment and the recognition of a problem is real. In some cases the lag is relatively short. However, lag phases may last centuries.

So we should not fall back on the argument, "that species has been here for years and it hasn't caused a problem yet." Instead, our decisions should be based on the characteristics of the species, the receiving environment and the history of the species in similar environments.

Selected characteristics of four invasive species are listed in table 2. These trees are among some of the most damaging species in Hawai'i. *Miconia calvenscens* is widely recognized as Hawai'i's worst weed. *Miconia* control has already cost the state over \$4 million and no end is in sight. Faya tree (*Myrica faya*) is a serious invader of higher elevation mesic forests. It is already a serious weed in Hawai'i Volcanoes National Park and surrounding public and private forests. Silk oak (*Grevillia robusta*) is rapidly taking over large expanses of dry forests on most of the main Hawaiian islands. Though there is some commercial interest in the species for sawtimber, loss of native habitat and control costs are mounting.

Table 2- Examples of Invasive Trees in Hawai'i:

Miconia (*Miconia calvenscens*)

- Bird and animal dispersed
- Forms dense monotypic stands
- Overtops and shades out native vegetation
- Threatens mesic and wet forests to 6000'
- Has cost Hawai'i over \$4 million and control is still far off.

Faya tree (*Myrica faya*)

- N-fixing- enhances invasion of other species
- Forms dense stands replacing native vegetation
- Bird and animal dispersed
- Possibly allelopathic
- Invades higher elevation mesic and wet forests

Silk oak (*Grevillia robusta*)

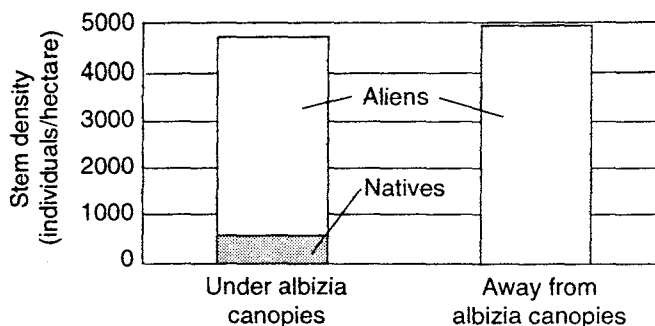
- Allelopathic
- Adapted to dry areas
- Fire adapted
- Wind dispersed
- Widely planted

Albizia (*Falcataria moluccana*)

- N-fixing, enhances invasion of other species
- Overtops and shades out native species ('ōhi'a)
- Rapid growing
- Widely seeded and planted
- Low elevation mesic forests

Albizia (*Falcataria moluccana*, also known as *Paraserianthes falcataria*), is invading many low-elevation mesic forests. Commercial interest in this species for

Figure 1. Stem density of tree species >2.0 cm diameter at breast height sampled in 0.01 hectare plots (n=10) located under and away from albizia canopies in Mālama Ki Forest Reserve (Hughes, pers. comm.).



timber or as a nitrogen fixer should be weighed against the potential for environmental impacts and control costs that will likely be born by society. Preliminary data, (Flint Hughes, US Forest Service, pers. comm.) indicates that *F. moluccana* can invade a wide variety of lowland habitats, including relatively un-weathered a'ā.

Albizia growing on 200-400 year old pahoehoe at Mālama Ki Forest Reserve on the Big Island apparently replace native dominated forests. Four-to-five year old albizia invading a 1955 flow on the Big Island is overtopping 40-45 year old 'ōhi'a. Hughes suspects that shade from over-topping albizia eliminates 'ōhi'a and other native species. Albizia also appears to set the stage for invasion by other weeds (see figure 1), perhaps through nitrogen enrichment of the site and modification of the light regime (Hughes, pers. comm.).

Considering Invasiveness in Species Selections for Forestry Applications

Species choices should be made based on the inter-relationship of many factors considered in an assessment that includes environmental and economic considerations and potential risks to the environment. The process is not unlike environmental assessments that are already conducted by many agencies for actions that might affect the human environment.

Regardless of the details, the process should be collaborative, participative, objective, transparent, and scientifically sound with gaps in data clearly stated.

Table 3- Factors to consider in species introductions to a new area:

- Potential to invade
- Economic impact (Potential food, fiber or goods)
- Diversity impact
- Ecosystem functioning and services impact
- Health and safety impact (e.g., fires)
- Cultural impacts
- Long-term site productivity and stability
- Ethical concerns
- Recall possibilities

If there is doubt about invasiveness there is good reason to error on the side of caution since 1) accurate prediction of invasion is difficult and uncertain, 2) it is difficult to predict where and when invasions will occur, and 3) it is difficult to predict what a particular invasive will do to an ecosystem with certainty.

Few regions, including Hawai'i, have objective methods for evaluating species for use or introduction. A screening system that can detect aggressive plant pests is urgently needed. The system's reliability in screen-

ing out minor invaders is less important (Daehler and Carino 2000).

Decision Tools-Species Lists:

Several tools are currently available to help guide species selection to reduce the risks associated with species new to an area. Lists of invasive species have long been the standard for determining "bad plants."

Lists have a long history and legal precedent, including state and federal "noxious weed" lists. Noxious weed lists have been useful and have the regulatory power to restrict movement, production and initiate control. Unfortunately, they also have often been a case of closing the door after the horse left the barn. In many cases the plant has already become widely established and is beyond realistic potential for eradication or meaningful control.

Precautionary lists have been developed for Hawai'i and other Pacific islands that address species that are either not here, not widely established or not established on

Table 4. Invasive species lists applicable to Hawai'i and other Pacific Islands.

Name	Geographic area covered	Source	Species listed	Internet address
Pacific Island Ecosystems at Risk	US affiliated Pacific Islands	J. Space, Pacific Islands Ecosystems at Risk	421	http://www.hear.org/pier
Pest Plants of Hawaiian Native Ecosystems	Hawai'i	C. Smith, University of Hawai'i Botany	149	http://www.botany.hawaii.edu/faculty/cw_smith/aliens.htm
Hawai'i Invasive Horticultural Plants	Hawai'i Division of and Wildlife	F. Kraus, Forestry	104	http://www.state.hi.us/dlnr/dofaw/hortweeds/
Hawai'i noxious weeds	Hawai'i	Hawai'i Department of Agriculture	79	http://www.hear.org/weeds/weedlists/usa/hi.htm
US noxious	United States	USDA Animal and Plant Health Inspection Service	96	http://www.aphis.usda.gov/ppq/weeds/fnwsbycat-e.html

all islands. The Pacific Island Ecosystems at Risk (PIER) list, compiled by Jim Space, lists 421 species invasive on US affiliated Pacific Islands (Federated States of Micronesia, Guam, Northern Marianas, Marshall Islands, American Samoa). Inclusion on the list is based on observed naturalization in the field, literature review and communication with expert colleagues. Though this does not include Hawai'i, it is useful to consider here, since many species on the list may become problematic here as well.

The list of Pest Plants of Hawaiian Native Ecosystems (UH Botany) includes 149 species observed to be invasive in Hawai'i. The list was initiated by Cliff Smith and is being maintained by the University of Hawai'i Botany department.

The Hawai'i Invasive Horticultural Plants list was compiled by Fred Kraus of the Hawai'i Department of Forestry and Wildlife (DOFAW). It lists 104 species that are currently in the nursery and landscaping trade that have been observed to be naturalizing and are apparently invasive in Hawai'i.

Though the lists are based on reasoned consideration, observation, and research conducted by the authors, the reasons for listing a species are often not apparent to the reader and may appear subjective. Certainly a more scientific approach would be more palatable for making decisions on species choice and some sort of model could serve as a predictive tool rather than a reactive one.

Decision Tools - Risk Assessment Systems

Models proposed by Pheloung (Australia), Tucker and Richardson (South Africa) and Reichard and Hamilton (North America) can be used to assess relative invasiveness based on the characteristics of the species and the receiving environment. A unifying theme in all of these systems is whether the species is known to be invasive in other areas with similar environmental and climatologically conditions. The goal of these systems is to predict the likely behavior of an immigrant species to a region (Daehler and Carino 2000).

These models have significant benefits over "bad plant" lists since they are considerably more objective, based on scientifically defensible principles, and are more understandable to the public.

Australian System (AQIS)

The Australian system was developed by Australian Quarantine and Inspection Service (AQIS, <http://www.aqis.gov.au/docs/plpolicy/wramanu.htm>) to evaluate species for introduction. The system is readily adaptable to Hawai'i. Curt Daehler (UH Mānoa) has found that with minor modifications the system can attain 90% accuracy in predicting invasive plants in the Hawaiian Islands.

The system evaluates answers to a set of 49 questions. If information is not available, questions can be skipped, as long as a minimum of ten questions are answered across a range of categories. Scores of "0" or less would "accept" a species for introduction. A score of 1 to 6 would require further evaluation before introduction and a score of greater than 6 would reject a species.

In Hawai'i the system does not have a regulatory role. However, the scores can serve as an indicator of a species' relative potential for invasiveness, with a lower score indicating a lower potential and a high score indicating greater invasive potential. The scoring of any species along that continuum is helpful information when making species selections, since "relative invasiveness" could be weighed along with other costs and benefits.

Daehler evaluated the Australian, South African and North American systems by scoring 54 known invasives of natural habitats lists species known to be invasive in Hawai'i to evaluate the system's accuracy at predicting invasiveness. He also scored 57 species not observed to be invasive to determine the system's accuracy at not rejecting non-invasives. The AQIS system performed better than the other two and appears to be well suited for Hawai'i with some minor modifications.

The AQIS system accurately predicts the invasiveness of known invasives, either "rejecting" (91%) or indicating, "need for further evaluation" (9%). No known invasives were "accepted".

The system also does a reasonably good job of not falsely indicating invasiveness for non-invasives. Of the 57 non-invasive species scored, 54% fell into the "accept" range. However 32% fell into the "need for further evaluation" category and 14% scored in the "reject" category.

Since falsely rejecting a potentially useful species could be costly through missed economic opportunity, it may be necessary to carefully evaluate the risk of invasiveness against other economic and environmental costs and benefits. Some economically useful species that are rejected can probably be substituted with native species or less risky exotics to yield similar economic benefits. This is particularly true for species in the "gray zone" at the margins of the "evaluate" and "reject" categories. However, species with higher scores should be looked at with great suspicion and rejected for use if there is a margin of doubt.

Evaluating forestry species commonly used in Hawai'i.

Tables 5 through 8 compare several "recommended" species lists against the PIER, UH-Botany, and DOFAW lists. The number of lists that a species appears on is noted. If the species has been scored using the AQIS system, the score is shown. A "?" under AQIS scoring indicates that the species has not been evaluated at this time.

Table 5 displays results for the four example invasive species discussed above. All four appear on at least one list and two scored >6 (Reject) on the AQIS scoring.

Table 5. Listing of four known invasive trees on PIER, UH-Botany and DOFAW invasive species lists and AQIS system scores.

Common Name	Scientific name	# Lists	AQIS
Miconia	<i>Miconia calvescens</i>	2	18-R
Faya Tree	<i>Myrica faya</i>	1	6-R
Albizia	<i>Falcataria moluccana</i>	2	?
Silk Oak	<i>Grevillia robusta</i>	3	?

Table 6. Listing of favorite forestry trees for Hawai'i (Friday) that also appear on PIER, UH-Botany and DOFAW invasive species lists and AQIS system scores

Common Name	Scientific name	# Lists	AQIS
auri	<i>Acacia auriculiformis</i>	1	6-R
	<i>Acacia mangium</i>	1	?
chocolate heart albizia	<i>Albizia chinensis</i>	1	?
	<i>Albizia lebbbeck</i>	1	4-E
kukui	<i>Aleurites moluccana</i>	1	?
neem	<i>Azadirachta indica</i>	1	?
	<i>Calliandra calothyrsus</i>	1	?
small-cone ironwood	<i>Casuarina cunninghamiana</i>	1	?
Spanish cedar	<i>Cedrela odorata</i>	1	?
rosewood	<i>Dalbergia sissoo</i>	1	21-R
Queensland maple	<i>Flindersia brayleyana</i>	2	?
madre de cacao	<i>Gliricidia sepium</i>	1	4-E
dry-zone mahogany	<i>Khaya senegalensis</i>	1	?
koa haole	<i>Leucaena leucocephala</i>	2	2-E
brushbox	<i>Lophostemon confertus</i>	2	?
pheasantwood	<i>Senna siamea</i>	1	?
West Indies mahogany	<i>Swietenia mahogani</i>	1	?
Australian toon	<i>Toona ciliata</i>	2	?

Table 7. Listing of shelterbelt/windbreak trees recommended by NRCS-Hawai'i that also appear on PIER, UH-Botany and DOFAW invasive species lists and AQIS system scores

Common Name	Scientific name	# Lists	AQIS
auri	<i>Acacia auriculiformis</i>	1	6-R
mangium	<i>Acacia mangium</i>	1	?
neem	<i>Azadirachta indica</i>	1	?
calliandra	<i>Calliandra calothyrsus</i>	1	?
small cone ironwood	<i>Casuarina cunninghamiana</i>	1	?
fern tree	<i>Filicium decipiens</i>	1	?
flemingia	<i>Flemingia macrophylla</i>	1	?
gliricidia	<i>Gliricidia sepium</i>	1	4- E
mock orange	<i>Murraya exotica</i>	1	?
dwarf brassaia	<i>Schefflera arboricola</i>	1	?
California pepper tree	<i>Schinus molle</i>	2	?
mahogany	<i>Swietenia mahogani</i>	1	?
turpentine tree	<i>Syncarpia glomulifera</i>	1	?
athel tamarisk	<i>Tamarix aphylla</i>	1	?
false kamani	<i>Terminalia catappa</i>	2	?

Table 8. Listing of shelterbelt/windbreak trees recommended by NRCS-Hawai'i that also appear on PIER, UH-Botany and DOFAW invasive species lists and AQIS

Common Name	Scientific name	# Lists	AQIS
ironwood	<i>Casuarina cunninghamiana</i>	1	?
shortleaf ironwood	<i>Casuarina equisetifolia</i>	3	15- R
bluegum	<i>Eucalyptus globulus</i>	2	?
brushbox	<i>Lophostemon confertus</i>	2	?
paperbark	<i>Melaleuca quinquenervia</i>	3	20
wild olive	<i>Olea europaea</i>	3	2 - E
Australian toon	<i>Toona ciliata</i>	2	?

J.B. Friday (UH-CTAHR) compiled a list of 45 "Favorite Forestry Trees for Hawai'i." Twenty-seven (60%) species of these species do not appear on the PIER, UH or DOFAW lists. Not appearing on a list does not necessarily mean that a species is not or will not be invasive, but it does imply that no one has observed the species invading native habitats at this time.

Eighteen (40%) species from the list do appear on one or more lists and several have already been rated using the AQIS system (Table 6). Of particular note, rosewood (*Dalbergia sissoo*) scores 21 on the AQIS system, putting it the portion of the invasiveness scale shared

with Miconia, clidemia, and lantana, three of Hawai'i's most serious weeds. The species listed in Table 6 should be regarded with caution and less invasive alternatives should be considered and additional information considered before planting them widely.

Of the 70 species on the list of suggested windbreak/shelterbelt trees from the Natural Resource Conservation Service, 15 (21%) appear on one or more of the three lists. Of these, two have been scored using the AQIS system. *Acacia auriculiformis* scored 6, the bottom end of the "reject" category. *Gliricidia sepium* scored 4, indicating need for further evaluation before use.

The Division of Forestry and Wildlife nursery produces 19 tree species for sale and distribution. Seven of these species appear on at least one list (Table 8). *Casuarina equisetifolia* scored 15 on the AQIS system, indicating the species' already proven invasiveness of near coastal habitats.

The paperbark grown in the DOFAW nursery (*Melaleuca quinquenervia*) scored 20 using the AQIS system.

Scores reported here are preliminary and may be modified as the AQIS system is refined for use in Hawai'i. In 2001 the US Forest Service, DOFAW and UH-Mānoa will score 150-200 species of interest in Hawai'i using a modified AQIS system (Daehler pers. comm.). Species to be scored will be selected with the assistance of the forestry, landscaping, and nursery professionals and will include important economic species. Suspected invasives (from UH and DOFAW lists) will be evaluated along with other species that are already in the trades or that may be potentially introduced into Hawai'i. An additional 150-200 species of concern for US affiliated Pacific islands will be scored in a cooperative effort of the Forest Service and UH- Mānoa. Findings will be peer reviewed and shared with all stakeholders via publications, workshops and the internet.

Results of this effort can be used by foresters, nursery and landscaping professionals to make species choices. Results might also be used to support industry standards, best management practices, green certification and education that would reduce the numbers of invasive species used or introduced to Hawai'i through landscaping, nursery and forestry trade.

If industry self-policing does not adequately address the growing problem of invasive species introduction, the results of this effort may provide a springboard for discussion of appropriate state regulations. Potential regu-

lations should be designed to protect the environmental well-being of Hawai'i while providing for the economic well-being of industries and businesses that rely on the use, sale, and distribution of plants for a variety of uses.

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Editor's note: For updates on the Hawai'i Weed Risk Assessment, see <http://www.botany.hawaii.edu/faculty/daehler/WRA>.

Keynote Speaker: Information Vital to Cost Effective Forestry: Using North Carolina for an Example

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Introduction

The forests of North Carolina are widespread and diverse. Natural and man-made disturbances of the past have shaped both the quantity and the many qualities of today's forests. North Carolinians value these forests which produce wildlife habitat, high-quality water, recreational and tourism opportunities and timber to support the states vibrant and large forest products industry.

Forests are dynamic and change can be dramatic and sudden or slow and tedious. Wildfire, hurricanes, tornadoes and other catastrophic events created sudden change in pre-historic forests while the natural processes of forest growth, aging and dying created another but slower evolution on acres not impacted by disastrous events. Native Americans impacted forests by slash and burn conversion to agriculture, the harvest of forests for fuel and other products and the use of fire in the forest for many purposes. European settlement hastened the conversion of native forests to other uses and accelerated timber harvesting. Eventually, effective and efficient fire control was introduced and wildfire became a rare, rather than common disturbance in forests. Early timber harvests of the mature virgin forests were, in most cases, complete and these harvests were often accompanied by intense fires creating the conditions which regenerated many of the forests which exist today. Abandonment of agricultural land created a different type of forest evolution over the landscape. In the mountains, the loss of the American chestnut to chestnut blight dramatically changed the landscape. A very limited forest land base has evolved virtually untouched by man. Each of these scenarios created a different forest condition and the result is the highly diverse and productive forests covering over 60% of North Carolina today.

Many are concerned about the future of our forests. Continued urbanization continues to eat away at the forest land base and many consider this to be the major threat. However, other changes, some very subtle, are occurring which are cause for concern. Populations of oak, hickory and several other species valuable for wood products and wildlife are declining and the populations of species such as red maple and sweetgum are increasing. These dramatic shifts are occurring as a direct result of fire exclusion and the common practice of repeated "*high-grading*," which removes high quality stems of valuable species such as oak while leaving small stems and less valuable species such as red maple. *Poor markets for low-grade and small diameter stems are the main reason high-grading was and is common in North Carolina.* The partially shaded ground conditions left after a high-grade harvest do not favor the regeneration of more sun-loving species such as oak, ash, black cherry, pines and many other species valuable for both wildlife habitat and forest products. Failure to disturb mature and over-mature forests by natural causes (particularly fire) or man (by forest management and timber harvesting) results in the same species shifts. The diminished frequency and intensity of timber harvesting and/or other disturbances on our public lands, such as our National Forests, is accelerating this trend on those acres.

The productivity and ecological character of North Carolina's future forests rest largely in the hands of over 300,000 private individuals and families who own 70% of the state's 18.4 million acres of commercial forest land. Owners cherish the forest for the economic, social and environmental benefits the forest provides. Timber harvesting and reforestation decisions are influenced by many things, including family situation, the current con-

dition of the forest, income needs and philosophy about land ownership and the environment. The collective decisions of private forest landowners will have long-term impact on the diversity, health and productivity of the forest landscape.

Forests have been shaped by natural processes and actions by current and previous owners. It is a widely held myth that a healthy forest is always an untouched forest, particularly if abusive practices, such as high-grading, have been used in the past. Active management may be required to preserve or restore desirable conditions in the forest. Active management begins with the development of a flexible plan which links your forest management and timber harvesting practices to long-term vision of the values expected of the forest. The assistance of professional wildlife biologists, foresters, soil and water specialists, recreation specialists, investment analysts and others are recommended as to develop a plan.

Elements of a Forest Management Plan

Planning is not a single step, but a series of continuous steps leading to desired forest ownership goals. Following are typical parts of a forest resources management plan:

1. Statement of landowner goals and objectives.
2. Location, including maps and boundary descriptions.
3. Stand descriptions and inventory data, including soil types, acreage, tree species, tree ages, stocking (numbers of trees), tree sizes, tree volumes, forest condition and health, specific water quality protection needs and description of the forest's importance to wildlife, recreation, aesthetics and natural plant communities.
4. Prescribed forest management activities for each sub-unit (stand) in the forest. Depending on the current condition of each stand, activities might include:

Re-growth or re-planting (regeneration practices) including site preparation, tree species and recommended techniques,

Forest fertilization, if soil tests deem it necessary,

Competing vegetation control (weeding),

Timber thinning to alleviate crowding,

Timber stand improvement to favor more desirable

tree species,

Ecological recommendations to enhance the stand's aesthetics, recreational uses, diversity of plants and wildlife species and appeal to wildlife species,

Installation and maintenance of Best Management Practices (BMPS) to protect water quality,

Final Harvests to renovate degraded stands or to regenerate mature/over-mature stands which have reached (or passed) their economic or biological peak,

Other requirements to comply with federal, state and local regulations.

Plans are unique to each owner and forest and can be modified at any time as conditions or objectives change. In North Carolina, a written and implemented forest management plan can also save property taxes under the NC Forestry Use-Value designation.

The Impacts of Timber Harvesting on the Forest

Commercial timber harvests in NC can be classified as:

- **Thinnings.** Enough space is needed for the development of selected crop trees. Commercial thinning produces some income from the sale of removed trees. Failure to thin crowded stands will cause the growth rate and vigor of the stand to decline, perhaps to the point where insects, diseases and stress kill trees. By allowing more sunlight to reach the crowns of the crop trees, growth, health and vigor are maintained or improved. Added benefits include the added growth of vegetation on the forest floor (understory) which increases food and cover for many wildlife species.
- **Improvement Cutting.** Middle age stands with a mixture of tree species can be improved by harvesting species and low quality stems which compete with more desirable trees in the stand for moisture, nutrients and sunlight. Trees removed can be used or sold for firewood, posts, pulpwood, sawtimber or other uses. By removing less desirable species and poorly formed, diseased or insect infested trees, this practice improves the species composition and stand quality. Improvement cutting can be used to improve wildlife habitat, aesthetics or timber production.

- **Final or regeneration harvest.** Stands which have reached maturity (either biological or economical), stands which lack the desired species of trees for wildlife, timber, aesthetics or other goals, and stands where past abuse has created unhealthy or low-productivity conditions can be harvested and regenerated. Sometimes an owner may harvest an area to create wildlife habitat or to create sunlit conditions for wildflowers or other plants which require large amounts of light. Natural regeneration, which relies on seed, sprouts or existing seedlings, may re-populate the harvested area if these sources are present in sufficient quantity and desired quality. If natural regeneration is judged not to be an option, seedlings or seed of selected species can be planted, assuming the selected species are well adapted to the soil/site and adequate site preparation and vegetation control is done to insure success. Regeneration harvest should be pre-planned, as effectiveness will vary depending on soil/site, tree species and stand conditions. Methods which might be used include: **single tree selection, group selection, seed tree, shelterwood and clearcutting.** The option selected must be compatible with the tree species and methods chosen to regenerate (particularly the light requirements of the species), and objectives for wildlife recreation, aesthetics, and timber production. If wildlife habitat manipulation is a key reason for timber harvesting, the owner must take into account adjoining ownerships to be sure that the timber harvest complements, rather than detracts from, the forest landscape habitat conditions.

Does Forest Management Pay for NC Landowners?

The complexity of sites, timber species mixes and landowner objectives makes it next to impossible to develop a general statement of financial returns from forest management. In addition, due to market imperfections, values of standing timber vary widely across the state. The following discussion serves to lead potential timber investors through the process of evaluating returns. The most common reforestation regime, artificial regeneration of loblolly pine, is used for example.

STEP 1. Evaluate the productivity of the site (site index). Foresters use site index (SI) as measure of site

productivity. SI is the total height to which dominant trees of a given species will grow on a given site by some index age, usually 25 or 50 years. For example, if the site index is determined to be (by actual tree measure or soil analysis) to be 70 at 50 years, foresters predict that trees planted on that site today will be 70 feet tall at 50 years of age. Once the forester determines SI, future timber yields can be predicted. Yields will vary depending on tree species, the number of trees per acre, frequency and intensity of thinnings, fertilization, intensity of weed control and the age of the stand when cut.

STEP 2. Estimate the cost of site preparation, tree planting and practices necessary to establish the stand. Reforestation costs depend on the condition of the site to be reforested and the intensity of practices used. Costs of site preparation may range from \$0-200 or more per acre. If the site is free of competing vegetation, no preparation may be necessary. This is sometimes the case if the site is clearcut cleanly or is an old field. Costs escalate as the need for competition control increases and will be greater for intensive management such as ditching, bedding, fertilization and intensive herbicide weed control.

The costs of planting or re-seeding will average \$70 per acre including seedlings and planting labor.

STEP 3. Estimate the costs of management activities that will be used to tend the growing stand. Prescribed burning, boundary line maintenance, fire line construction and maintenance, weed control and insect/disease protection all cost money. However, these costs are fairly low and periodic and usually will not exceed \$5 per acre per year if spread over the life of the stand.

STEP 4. Estimate future timber yield and value. Future yield can be predicted if one knows the site index and the timber management regime to be used over the life of the stand (species, trees per acre, thinning schedule, fertilization schedule, weed control intensity etc.). In NC, due to poor competitive markets for pulpwood, landowner returns will increase if they hold timber an appropriate time to produce sawtimber. Pulpwood prices in NC have fallen behind to inflation, while sawtimber prices have increased on average about 1% above the rate of average annual inflation.

Profitability can be measured in a number of ways. Most private landowners will understand and relate to Net Present Value (NPV), Net Annual Equivalent (NAE) or Return on Investment (ROI). **NPV** is today's value of expected future returns minus today's value of future costs. Investments with positive NPV yield a higher return than the interest rate used to discount future incomes and costs to the present. **NAE** is the conversion of NPV to an equal annual amount over the life of the investment. **ROI** is the internal rate of return of the investment. It is the compound interest that equates the present value of future incomes with the present value of future costs. An investment is judged acceptable if the ROI is higher than a pre-selected threshold interest rate.

Very few private non-industrial landowners in NC manage as intensively as does forest industry. Frankly, with poor pulpwood markets, difficulties in getting thinnings accomplished and longer sawtimber rotations required, it is economically impractical for small ownerships to be managed intensively. Forest industry uses fertilization, herbicide weed control and intensive intermediate stand management regimes and the result is higher yield, but at significant increased cost of production. While this results in 30-60% higher fiber yield, the economic acceptability of this type of management is unique to large ownerships.

Basis assumptions for our economic analysis examples are:

1. All incomes are pre-tax.
2. After tax management costs are \$2 per acre per year.
3. The rotation age is 35 years, assuming 350 trees per acre initially with no thinnings.
4. Discount rate of 4%, approximating the real rate of return to productive capital investment for the past 40 years.
5. Current statewide average of \$245 per thousand board feet (Scribner) for sawtimber, \$16.08 per cord for pine pulpwood and \$60.87 per cord for small sawlogs (chip and saw). The impact of a sustained increase of 1% above inflation versus no increase is included for sawtimber and chip and saw. Pulpwood prices are assumed to stay the same in all examples.
6. Cost-sharing will reimburse the landowner 40 percent of the reforestation cost.
7. The landowner is assumed to claim the federal 10% investment credit and writes off 95% of the reforestation cost as amortized deductions over the 84 months beginning in the year of reforestation. The taxpayer is in the 28% marginal tax bracket.

For Example 1, total costs of reforestation are \$165 per acre with post cost-share and tax incentives out-of-pocket costs of \$47.51. For Example 2, the total cost of reforestation is \$65 per acre which nets to \$18.73 after cost-share and tax incentives.

Example 1. Returns from a \$165 per acre investment for loblolly pine.

Site Index(25)	<u>1 percent Sawtimber Price Increase</u>			<u>No Price Increase</u>		
	NPV	NAE	ROI(%)	NPV	NAE	ROI(%)
50	\$257	\$13.79	9.06	\$173	\$9.21	8.04
60	491	26.31	10.90	345	18.47	9.87
65	678	36.31	11.89	480	25.71	10.83
70	867	46.47	12.67	617	33.04	11.59

Example 2. Returns from a \$65 per acre investment for loblolly pine.

Site Index(25)	<u>1 percent Sawtimber Price Increase</u>			<u>No Price Increase</u>		
	NPV	NAE	ROI(%)	NPV	NAE	ROI(%)
50	\$285	\$15.27	11.03	\$200	\$10.69	9.95
60	519	27.79	12.97	372	19.95	11.88
65	705	37.79	14.01	508	27.19	12.90
70	895	47.95	14.83	644	34.52	13.70

RETURNS FROM LOBLOLLY PINE PLANTATION MANAGEMENT CAN EASILY AVERAGE 10% RETURN ON INVESTMENT OR HIGHER.

Many forest landowners are comparing returns from managed forests with other investment opportunities and are increasing investments in forest management. Management of mixed hardwood stands, other pine species, both in plantations and natural stands, can be profitable, as well, but the costs, incomes and time frame of the investment will vary widely.

The bottom line for North Carolina forest landowners and landowners every where is that objectives must be set, soils must be evaluated, tree species selected and local markets must be considered when evaluating a forestry investment. When these things are considered and the advice of a forest resources professional is sought and heeded, forestry will be a sound investment.

Government Incentive Programs for Forestry

Ron Peyton, District Conservationist
USDA NRCS, Līhu'e

The typical questions people have about government cost share programs are:

1. How much money can I get?
2. Where do I get the money?
3. When can I put the money in the bank?

The answers they really want to hear are: All the money you want, right here, and right now. Well, that isn't how most cost-share or grant programs work. Cost share incentive and grant opportunities are out there, not only from the federal government, but also from the state, county, and numerous organizations and foundations. J.B. and Katie Friday have prepared a cost share matrix describing some of the major programs and their specifics. This matrix is included in your conference packet. I would like to stress two points before talking about specific programs.

1. As with any sound business or investment opportunity you need a good business and resource management plan. The key to a good plan is a well thought out objective. What do you plan on doing, why, and how are you going to do it? Many people seem to be chasing funding dollars first, then trying to match program specifics and restrictions to what they hope to do. I recommend deciding first what you want to do and then look for funding opportunities that match what you want to do.
2. The implementation of good conservation practices does not *COST*; it *PAYS*.

We have all heard that there is no "Free Lunch"; well, there isn't any free money either. All grants and cost-share programs that I know of come with various

types of restrictions, strings, obligations, or conditions. You will have to decide if pursuing a specific funding program is worth your time and effort. One of the major efforts of our local field office delivery and servicing of the various cost-share assistance programs such as:

- WHIP – Wildlife Habitat Incentive Program
- EQIP – Environmental Quality Incentive Program
- CRP – Conservation Reserve Program
- CREP – Continuous CRP
- FIP – Forestry Incentive Program
- SIP – Stewardship Incentive Program
- WRP – Wetland Reserve Program

From experience I can assure you that each program is different, programs change, and new programs take time to implement. (As an example: many features of the 1995 Federal Farm Bill didn't start getting applied on the land until about 1998.)

We are already starting to see much discussion and debate about the new Federal Farm Bill being planned for sometime in 2002 – 2005. The last major change to Farm Bill programs was the 1995 Farm Bill, which we are still trying to figure out how to implement. Also, there are many features authorized in prior legislation that have never been actually implemented or funded.

Just recently we were instructed by the new US Secretary of Agriculture, Ann Veneman, to no longer use the term "FARM BILL" but instead use the term "FARM POLICY LEGISLATION"

Another new program being considered is called "CSA" or the "Conservation Security Act", which was introduced May 22, 2001 by Senators Tom Harkin (D-IA) and Gordon Smith (R-OR) as S.932; and Representen-

tatives Marcy Kaptur (D-OH) and John Thune (R-SD) as H.R.1949. An additional sixteen senators and representatives are cosponsors of each legislative action. Under the proposed act Farmers and Ranchers would receive payment for voluntarily maintaining or adopting conservation practices that enhance the environment, natural resources and wildlife habitat. (See eNotes from NACD, May 29, 2001, <http://www.nacdnet.org/eNotes> Also, see <http://fb-net.org/FB/CSA/> for Senator Harkin's statement made on introduction of S.932, a copy of S.932 and links to HR 1949)

If implemented as proposed this new program could drastically change federal assistance programs for years to come.

Another unknown is the new political structure and the administration. This could also impact the next four to eight years. The president's new proposed budget for 2002 eliminated funding for all programs except EQIP and CRP.

So what about the "FIP" – Forestry Incentive program? It is being negotiated by the House and Senate and we just don't know yet. Historically, FIP was a well-funded program, especially in the Deep South, east of the Mississippi River. Very little cost share dollars ever got allocated west of the Rocky Mountains.

This year in Hawai'i the FIP program had a one month open season in March. Statewide there was only \$14,200 available and we had twenty individuals sign up requesting over \$80,000 in assistance. Applications are now being evaluated and ranked. The highest rated projects will be funded until the money runs out.

This example points out several features of most cost-share programs:

1. There is never enough money to go around or satisfy all needs.
2. This is a specific sign-up period, usually once per year.
3. There is a statewide ranking process that can take time.
4. Many programs have caps or limits. (FIP is \$10,000 per contract)
5. Eligibility requirements for individuals and land vary between programs.
6. Program schedules, timing, etc. may not match when you are ready or able to do implementation of a project or acquire tree-planting stock.
7. Programs often require a lot of paperwork, signatures, reviews, and red-tape.
8. Programs often require planting trees or shrubs from

local sources, which may not be readily available.

9. Assistance received each year is reported on IRS-1099 form and treated as income on which you pay taxes. (This could put you into a higher tax bracket)
10. Payments are not up-front. They are reimbursement based on valid receipts after the practice has been installed, inspected, and approved.

Many landowners have opted to have nothing to do with cost-share programs, feeling that it just isn't worth the effort.

However, even without cost-share assistance there is a tremendous amount of other assistance available, such as soils maps and information, maps and aerial photos, plant information, management planning assistance, and information on conservation standards and specifications. Also, there is tremendous information available on the World Wide Web and from various associations, nurseries, and private consultants.

Depending on how your business or enterprise is set up, the Federal Income Tax schedule "F" is an often overlooked or underutilized process to document expenses and investments and reduce annual tax liabilities.

The best time to plant a tree is yesterday, the next best time is today.

I challenge you to:

- Never stop learning or asking questions.
- Get active on the internet.
- Find out what resources are available locally.
- Get active – join or start an organization .
- Try things – innovate, evaluate, document, and share results.
- Get active in local issues: zoning, taxes, greenbelts.
- Work with and get to know local people who are doing similar things.

Government incentive programs which can include tree-planting or forest management
August 9, 2002

Katie Friday, USDA Forest Service

J. B. Friday, University of Hawaii CTAHR Cooperative Extension Service

Program name	Purposes	Administered by	Land eligibility	Incentive	Time-frame	Other requirements
Forest Stewardship Program (FSP)	(1) plan development (2) reforestation & afforestation (3) forest & agroforest improvement (4) windbreak & hedgerow establishment, maintenance and renovation (5) soil & water protection & improvement (6) riparian and wetland protection and improvement (8) wildlife habitat improvement (9) forest recreation enhancement	DOFAW County offices; Kari Dalla Rosa (587-0166)	private, privately leased lands (10-year minimum lease), minimum 5 contiguous acres in FSP project	up to 50-50 cost-share, usually limited to \$75,000/year	10-year minimum	Pre-proposal, land management plan and EA required. Existing forests of Natural Area quality ineligible for timber management objectives.
Forest Land Enhancement Program (FLEP) <i>Beginning in 2003</i>	(1) Establish and maintain non-industrial private forest lands (2) Enhance productivity of timber, fish, and wildlife habitat and soil, water, and air quality (3) Assist non-industrial private land owners	DOFAW	Non-industrial private forest lands up to 1000 acres	Cost share rates to be determined		
Forestry Incentives Program (FIP) <i>To be replaced by FLEP program (above)</i>	"to increase the supply of timber products from non-industrial private forest lands" Tree planting, site preparation, weed control	USDA NRCS	private, privately leased lands (10-year minimum lease); ownership less than 1000 acres forest land, no minimum acreage Land must be capable of producing at least 50 cubic feet of wood per acre per year	up to 50-50 cost-share, maximum \$10,000/year	10-year minimum, 1 year contracts	according to the Hawaii FIP Plan, lands with sensitive environmental concerns should be directed to the state FSP

Conservation Reserve Program (CRP)	"conserve and enhance soil, water... grazing land, wetland, and wildlife habitat"	USDA NRCS	private or private 10-15+ year lease of private land <u>marginal pastureland</u> or cropland with a recent cropping history meeting certain soil & water criteria	Annual rental payments plus up to 50-50 cost share	10-15-year contracts	Cease production of agricultural commodities; allows appropriate timber management, including profitable thinning
Environmental Quality Incentives Program (EQIP)	"conserve and enhance soil, water... grazing land, wetland, and wildlife habitat" examples include riparian forest buffers	USDA NRCS	private or private 5-10+ year lease of private land cropland, rangeland, pasture, <u>forest</u> , other farm or ranch land;	up to 75-25 cost share (75% federal, 25% matching)	5-10-year contracts	applicants must be persons actively engaged in livestock or agricultural [or forest] production
EQIP "Conservation Priority Areas"	Year 2002 Hamakua, Lower Hamakua Ditch, Kau, Puna, Wood Valley, Molokai East					
EQIP "Statewide Concerns:"	Year 2002 <u>Sediment in Surface Water</u> ; <u>Noxious Weed Control</u> (can include replacement tree planting); Animal Waste Management		For noxious weed control: "If idle land was cropped within the past 5 years and it will again be cropped within the year, land is eligible"			
Wildlife Habitat Incentives Program (WHIP)	Restore unique native habitats, especially for threatened and endangered plant and animal species..." including noxious weed control	USDA NRCS	private (state and county lands also eligible, lower priority; leased federal lands eligible) Priority habitats for Hawaii: <u>Native forests</u> , montane bogs, wetlands, riparian areas, caves with rare species, coastal dunes	up to 75-25 cost share (75% federal, 25% matching), usual maximum \$10,000/year	minimum 10-year contract	
Natural Areas Partnership (NAP)	Conservation and restoration of native ecosystems	DOFAW NARS Commission Executive Secretary 587-0063	private lands of "natural area" quality: intact native ecosystems, essential habitat for endangered species	up to 2:1 cost-share (67% state, 33% applicant funds)	permanent dedication through transfer of fee title or conservation easement	applicant must be landowner or cooperating entity managing private lands (non-profit or other body approved by DLNR)

Urban & Community Forestry (U&CF) Kaula nani	Tree planting in urban and community settings, educational programs, technical tree-care programs, Arbor Day activities "Where people live, work and play"	DOFAW Teresa Trueman-Madriaga, 672-3383	public lands or public access	up to 50-50 cost-share, maximum \$10,000/year		Applicant must be non-profit organizations, tree advocacy groups, civic groups, educational institutions, and local and state government agencies
Federal income taxes	timber production	IRS (UH CES has publication, contact JB Friday, 959-9155)		deduction or amortization of planting costs - up to approximately \$10,000 over 7 years		
Tree Farm	sustained production of forest products in quantity sufficient to establish a business	DOFAW 587-0166	private property or lease of more than 20 years	"Right to Harvest" law applies		Management plan to be approved by DLNR
Kauai County property tax incentives	Tree farm development	Kauai County Tax Office	Private property or lease, min 10 acres	Exemption from real property tax except for minimum \$25/TMK		Management plan
Hawaii County property tax incentives	Production forestry	Hawaii County Tax Office	Private property or lease	Low tax assessments		Management plan to be approved by DLNR
Hawaii County property tax incentives	Native forest	Hawaii County Tax Office	Private property or lease of at least 20 yrs, min 5 acres, at least 60% cover native plant species	Low tax assessments	20 year dedication	Management plan to be approved by DLNR

For more information on NRCS cost-share programs, see NRCS website: <http://www.hi.nrcs.usda.gov/programs.htm>

Managing Koa for Eventual Commercial Purposes

Peter Simmons
Kamehameha Schools

I was asked to update the conference as to who is managing land for commercial koa production and how many acres are being managed for this purpose.

First some caveats. Some landowners are augmenting koa with the idea of creating an abundant resource for later consideration of harvesting. For instance, the Kamehameha Schools project at Keauhou Ranch is evolving, and our concepts of how much may be harvested are evolving. We are certain about one thing – we want to reforest and rejuvenate the koa and 'ōhi'a forests that have over the last hundred years supplied our licensees, the timber industry, and us with over 200 million board feet of koa. About half of the projects below, counted by acreage, are mature commitments; others are between infancy and adolescence.

So let's not be misled by simply counting thousands of acres being managed with commercial use in mind. There is still much to be done to create the kind of commercial base that a proper industry needs to be robust and at the same time respect the abundance of other native life forms in our forests.

Here then is a loose accounting:

Landowner	Acres	Comments
State of Hawai'i	1,200	Kapāpala, Ka'u, for sustainable cultural use
	3,000	Kapāpala, Ka'u (former sugar land under consideration for sustainable commercial management)
'Umikoa Ranch	2,000	Hāmākua; part of the Forest Stewardship program
Kamehameha Schools	5,000	Lands mauka of Hōnaunau Forest, North and South Kona
	8,000	Hōnaunau Forest, North Kona
	5,000	Keauhou Ranch, Ka'u (commercial potential without conflict with rare plants and animals)
The Nature Conservancy, Hawai'i	2,000	Honomalino, South Kona
Kealakekua Ranch	3,000	Includes planted acres and those managed for koa
Maui Land and Pineapple Company		Evaluating potential
Projects of less than 1,000 acres	1,000	Many smaller landowners are planting 10 acres or less, some larger land owners are considering projects.
TOTAL	30,200	

Koa Silviculture

A Realistic Economic Model

Max Hensley

Principal Risk Factors

Landowners thinking about growing koa must face many risk factors. First among these are political risks: will an endangered species take up residence in the koa and prevent harvesting? Will public opposition to cutting trees prevent a landowner from logging in stands he has grown?

Biological risks include pests and diseases. The twig borer (*Xylosandrus compactus*) attacks growing shoots. *Fusarium oxysporum* is a fungal wilt disease that kills koa trees outright and has been devastating in some plantations at lower elevations. In other situations, koa stands have declined without a cause being identified.

Other risks include drought, windthrow, and fire. Koa will always have a limited and specialized market, due to its high value and cultural affinity with Hawai'i. Poaching is a constant worry for landowners, and landowners must also be concerned with access easement restrictions and property taxes.

The following financial analysis was done using the CTAHR spreadsheet model for financial analysis for tree farming in Hawai'i, available on the internet at <http://www2.ctahr.hawaii.edu/forestry/>. The analysis is based on a hypothetical site with the following characteristics:

- 100 acres on windward Hawai'i Island
- Currently in pasture
- Elevation about 4,000 feet
- Koa naturally the dominant tree
- Deep ash-derived soils
- Rainfall about 2,500 mm/year (= about 100 inches/year)

- Current vegetation includes widely scattered senescent koa

Cost assumptions are as follows:

- Land costs for years 1 to 42 are \$4,000/yr
 - $2\%/yr \times \$2,000/a \times 100 a = \$4,000/yr$
- Land closing costs in year 1 are \$5,000
- Fencing costs in year 1 are \$16,500
 - 5-strand barbed wire @ \$1.50/ft x 10,600 ft + 2 steel gates @ \$300 = \$16,500
- Bulldozer costs for scarification, roads, and firebreak are \$15,000/yr for years 1, 2, and 3
 - Bulldozer costs @ \$450/acre x 33.3 a/yr scarified each year
- Supplemental plantings are \$5,250/yr for years 2, 3, and 4
 - Cost of superior seedlings, labor, and fertilizer @ \$1.50/seedling x 500 seedlings/a x 7 acres in need of replanting per year = \$5,250
- Professional services
 - Year 1 \$500
 - Years 2 through 4 \$200/yr
 - Years 10 and 38 through 42 \$700/year
 - These costs assume that the owner is present on site and substantially involved in the project.
- Taxes \$40/yr
 - Code 8J Hawai'i County: Average pasture, slow rotation forestry with 20 year dedication. Rate is \$40/a; $\$40 \times 1\% \times 100 \text{ acres} = \40
- Thinning Year 10 \$20,010
 - Remove 4 culls around each of 120 projected crop trees/a @ \$0.50/cull x 79 a = \$18,960
 - Thin supplemental planted acreage: 100 culls/a x \$0.50/cull x 21 a = \$1,050
- Liability insurance \$500/yr

- Fire break and fence maintenance \$150/yr

Yield analysis

- Thinnings at year 10: no commercial value
- Grazing: no commercial value
- Intercropping: no commercial value
- Hunting licenses: no commercial value
- Stumpage years 38 through 42: \$500,000/yr
 - o 80 crop trees/a x 125 bf/tree x \$2.50/bf x 20 a/yr = \$500,000/yr
 - o Yield at years 38 through 42 is 10,000 bf/a
 - o Assumes <= 10% of trees with genetic curl

Table 1 shows costs and yield assumptions taken from the spreadsheet model.

Financial Calculations for Tree Farmers in Hawaii

Sample calculations for a mauka koa scarification project

Age (years)	Yields	Value	Unit
	20	0.0	mbf/acre
	30	0.0	mbf/acre
	35	10.0	mbf/acre
	40	10.0	mbf/acre
	45	10.0	mbf/acre
	50	0.0	mbf/acre
	55	0.0	mbf/acre
	60	0.0	mbf/acre
Real Increase in Stumpage Value		0.0	%/year
Thinning Revenues			
No. of stems removed at year 5		200	stems/acre
Price of stems removed at year 5		0	\$/stem
No. of stems removed at year 15		200	stems/acre
Net price of stems removed at year 15		0	\$/stem
Costs			
Thinning cost		300	\$/acre
Site establishment costs			
Management costs		5	\$/acre
Initial herbicide		60	\$/acre
Land closing costs		10	\$/acre
Land survey		25	\$/acre
Scarification		450	\$/acre

Spot herbicide application	30	\$/acre
Commercial HFIA membership	0	\$/acre
Safe Harbor agreement	0	\$/acre
Superior seedlings	1.25	\$/seedling
(21 ac x 500 seedlings/ac)/100 ac	105	seedlings/acre
Cost of seedlings	131.25	\$/acre
Planting and fertilizing 21 ac	26.25	\$/acre
5-wire barbed wire fencing + 2 gates	165	\$/acre
Interim weed control	0	\$/acre
3 month fertilizer application	0	\$/acre
Annual operating costs		
Stand maintenance	5	\$/acre/year
Property insurance	5	\$/acre/year
Fence and firebreak maintenance	15	\$/acre/year
Management costs	5	\$/acre/year
Land costs	40	\$/acre/year
Property taxes	4	\$/acre/year

The spreadsheet model returns a table of calculated Net Present Values (NPVs), in dollars per acre, for each of two discount rates and three stumpage rates. Negative NPVs indicate a money-losing proposition, positive NPVs indicate a profit-making proposition. NPVs may be used to compare different investment opportunities.

Table 2. Calculated Net Present Values.

Stumpage, \$/mbf	2,000.00		2,500.00		3,000.00	
Discount rate	4.0%	7.0%	4.0%	7.0%	4.0%	7.0%
Year	Net Present Value, \$/acre					
35	2,834	59	4,101	528	5,368	996
40	1,860	(503)	2,901	(169)	3,942	165
45	1,058	(904)	1,914	(666)	2,770	(428)

Internal rates of return (IRRs) may also be used to compare one investment with another. IRRs are calculated by setting the NPV to about zero at year 40. Table 3 shows the IRR of koa scarification forestry at three different stumpage prices.

Table 3. Internal Rates of Return.

Stumpage, \$/mbf	2,000.00		2,500.00		3,000.00	
Internal rate of return	6.1%		6.8%		7.4%	
Year	Net Present Value, \$/acre					
35	600		664		694	
40	(79)		(63)		(68)	
45	(584)		(586)		(601)	

A sensitivity analysis may be performed by changing the assumptions for costs and returns that go into the model and seeing how these changes in the variables modify the Internal Rate of Return. Sensitivity analyses may be used to select the best management strategies or to see how critical certain assumptions are to the model output.

	IRR (%)	Change in IRR (%)
Prototype projection, baseline scenario (@\$2,500/mbf)	6.8	
1. 1%/yr real price increase in koa stumpage	8.1	+1.3
2. Land costs \$4,000/acre	5.8	-1.0
3. No supplemental plantings	7.2	+0.3
4. Replace scarification with seedlings	5.3	-1.5
5. Double the percentage of curly koa	7.4	+0.6
6. Yield is 15 mbf/a, not 10 mbf/a	8.1	+1.3
7. Yield is 20 mbf/a; rotation 20 years	21.0	+14.2
8. Return from other forestry projects (Roger Dickie, NZ)	8.65	
Comparison with other investments: real rate of return = % rate of return – inflation		
1. US long bonds	~3	
2. Corporate junk bonds	~9	
3. Commercial real estate	~8	

Table 4. Retail lumber prices of other high-value hardwoods

Common name	Scientific name	Retail price range in \$/bf
Koa	<i>Acacia koa</i>	\$15.00–\$26.95
Curly koa	<i>Acacia koa</i>	\$20.00–\$60.00
Ebony (Gabon)	<i>Diospyros crassiflora</i>	\$49.00–\$72.00
Holly	<i>Ilex opaca</i>	\$10.50–\$18.75
Honduras mahogany	<i>Swietenia macrophylla</i>	\$5.00–\$10.75
Narra	<i>Pterocarpus indicus</i>	\$9.74–\$11.25
Australian lacewood	<i>Cardwellia sublimis</i>	\$8.90–\$14.50
Indian rosewood	<i>Dalbergia latifolia</i>	\$14.99–\$35.00
Silk oak	<i>Grevillea robusta</i>	\$5.00–\$10.75
Teak	<i>Tectona grandis</i>	\$14.99–\$16.00
Pecan	<i>Carya illinoensis</i>	\$4.00
Prima vera	<i>Cybistax</i> (syn. <i>Roseodendron</i>) <i>donnell-smithii</i>	\$7.75
Walnut	<i>Juglans nigra</i>	\$4.25–\$7.29
Oak	<i>Quercus</i> spp.	\$3.32–\$3.89
Blackwood acacia	<i>Acacia melanoxylon</i>	\$4.75

There are many options for the landowner to improve the IRR for koa forestry. These include:

- Vertically integrate your operation
 - Custom mill your own timber
 - Kiln dry your product
 - Develop market niches
 - Market direct to retail
 - Make finished products
- Improve the genetics of koa
 - Begin controlled crosses
 - Select for color
 - Select for curl
 - Select for form
- Develop veneer logs
 - Prune judiciously
 - Train for straight boles
 - Check color
- Take personal tax advantages
 - Shelter: MAI not taxed
 - Limited federal write-offs
- Participate in government cost-sharing programs

Summary:

Realistic prognosis for koa silviculture

- Major risk factors are drought, political issues, and prevalence of dormant seed in seed banks.
- IRR for scarification koa under likely assumptions is comparable to the returns on other risky investments.
- IRR can be increased substantially by actively managing the project.
- Investors in modest-sized, economic koa projects are completely blocked by the lack of long-term leases or small, reasonably priced fee simple or condo parcels suitable for koa.

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Research Update: the University of Hawai'i at Hilo College of Agriculture, Forestry and Natural Resource Management

Randy S. Senock, Assistant Professor

Forestry research at UH Hilo includes investigations into both plantation forestry and management and function of native forests.

The National Science Foundation has funded a major study on the sustainability of plantation forestry. Topics being investigated include:

- Changes in soil nutrients under different species and how long these changes last after harvest and re-planting
- Biomass production of pure stands and mixed stands with nitrogen-fixing species
- Biodiversity under plantations of exotic trees
- Soil strength and erosion under different harvesting technologies (partly funded by the County of Hawai'i Research and Development)
- Effects of silviculture on water quality (in cooperation with the UHHR Council)

CAFNR maintains a low-elevation hardwood trial of pure stands of promising high-value native and exotic timber trees and mixed stands with nitrogen-fixing species. Species include rainbow gum (*Eucalyptus deglupta*), yemane (*Gmelina arborea*), narra (*Pterocarpus indicus*), kamani (*Calophyllum inophyllum*), milo (*Thespesia populnea*), kou (*Cordia subcordata*), and naio (*Myoporum sandwicense*), intercropped with *Acacia angustissima* as a nitrogen-fixer. A common garden of different genotypes of ohia (*Metrosideros polymorpha*) is also part of the demonstration. Results from this trial are valuable for landowners selecting species to plant and for students studying growth eco-physiology of the trees and the soil-building properties of the nitrogen-fixing species.

Research on *Acacia koa* includes studies and class work on stand management of natural and planted stands at 'Umikoa ranch and on low-elevation natural regeneration of koa at C. Brewer's Pauka'a area, a former cane field.

Since the value of forests in Hawai'i is more often for ecosystem services than for timber production, research has also been conducted in forest hydrology, especially in the Kohala Cloud Forest. Students and faculty have studied the regional water balance, including environmental inputs such as rainfall, throughfall, and fog deposition; environmental factors such as solar radiation and temperature; and influences of native versus exotic vegetation.

A major part of the UH Hilo forestry program has been Work Force Development. This has been a cooperative effort with:

- Hawai'i Community College Office of Continuing Education & Training
- The state Department of Labor and Industrial Relations / Work Force Development program
- The state Department of Hawaiian Home Lands
- The Kekua Foundation

The Work Force Development project has emphasized forestry skills training in road construction, tree felling, timber harvesting, and construction, using state of the art machinery brought in for the purpose. The highlight of the program was the harvest and processing of 20-year-old experimental eucalyptus and albizia plantations in Chin Chuck and Kamae on the Hāmākua Coast. The harvest operation integrated UHH professors, US Forest Service professionals, employees from the Workforce

Development Agency and UH Hilo students creating a unique learning experience and valuable vocational training. Participants were trained on a Clearwater yarder, a harvesting machine which utilizes cables to suspend a log, dramatically reducing ground disturbance during a harvest, a Timberjack 735 Shovel Logger, and a Timberjack 1210B Forwarder. As the Work Force Development program included value-added processing of the harvested timber, participants learned about milling and construction as well. A two-way band-cut mill was used to make dimensional lumber from the harvested eucalyptus, and cut lumber was dried at Winkler Woods

in Hilo. Some of the lumber was used for flooring, although there are many uses of this species. A small log cabin was constructed exclusively with *Eucalyptus saligna*.

In summary, the UH Hilo Tropical Forestry Program seeks to foster both sustainable forestry and sustainable communities, through research, education, and outreach in technical, biological, and social aspects of forestry. For more information, see <http://www.uhh.hawaii.edu/~cafnm/TFP/index.htm>.

Research Update: University of Hawaii at Mānoa

J. B. Friday, UH Mānoa CTAHR

Forestry research at CTAHR includes not only the traditional fields of forest ecology and silviculture, but also research in fields of interest to tree farmers such as agroforestry, genetics, soil science, and pathology.

CTAHR has been a leader in koa forestry research. A project conducted in Kamehameha Schools' Hōnaunau forest on the Kona coast of the Big Island by Adrian Ares and Jim Fownes found relationships between koa growth and water supply. Measuring koa growth along a gradient of mid-elevation, wetter sites to high-elevation, drier sites, the researchers found:

- Better growth on 'a'ā lava substrate than on pāhoehoe lava substrate
- Better growth at lower (wetter) than higher (drier) sites in Hōnaunau
- Results which agree with other studies on opposite gradient on Kaua'i (lower, drier sites to higher, wetter ones)
- Estimation of productivity of koa sites (in Hōnaunau ~ 200 bf/acre/year)

Work done on koa genetics and selection of superior koa varieties by James Brewbaker of CTAHR and Nicklos Dudley of HARC at the CTAHR Hāmākua Research Station has focused on:

- Heritability of growth rates, bole form and quality
- Identifying resistance to koa decline
- Microbiology of koa (its *rhizobia* and *mycorrhizae*)
- Seed production of superior selections

Since 1990, over 500 families of koa have been tested. New trials are planted every year. Results to date indicate that:

- Koa is out-crossing and highly variable

- Koa is a very fast-growing tree
- Most koa trees are poor genetic parents
- Koa seeds can be harvested in 4 years from the time of planting
- Koa has serious disease problems that limit it at present to high elevations

A research project in eucalyptus stands on the Hāmākua coast is seeking to answer the classic forestry question of why stand production peaks and then declines with age. The research has been carried out by Christian Giardina of CTAHR, Randy Senock of CTAHR and UH-Hilo CAFNRM, James Fownes of CTAHR and U Mass, Dan Binkley of Colorado State University, and Michael Ryan of the USDA Forest Service in Fort Collins. Results to date have indicated that neither wood and root respiration, nor water limitations are the reason for the decline in productivity. Other results are that:

- Higher levels of fertilization results in the same root growth but more stem growth
- Growth increases even with late (mid-rotation) fertilization for short-rotation stands
- 18-year old stands show a significant response to fertilization

CTAHR's Susan Miyasaka and Mitiku Habte have investigated the use of mycorrhizal fungi for early establishment of native trees. They have found that:

- Beneficial fungi help tree roots take up water and nutrients
- Mycorrhizal inoculation improved early growth and nutrient uptake of koa in field, may also be important for mamane & other species
- Benefits depend on planting site. Trees on degraded sites are more likely to benefit.

They are currently developing mycorrhizal inoculation techniques for use in local nurseries.

On Moloka'i, CTAHR extension agents Kali Arce and Alton Arakaki have worked developing alley-cropping systems using the Hawaiian trees milo (*Thespesia populnea*), kou (*Cordia subcordata*), kamani (*Calophyllum inophyllum*), and kukui (*Aleurites moluccana*). The first three trees are valuable as timber species, and all four are culturally important to Moloka'i and Hawai'i. Understory crops selected for use in the system are adapted to increasing shade as the trees grow. Alfalfa has been replaced by ginger and kava. Pepeiao mushrooms are grown on cut branches of the trees.

In an alley-cropping project on Kaua'i, J. B. Friday and Jim Fownes investigated competition for light between trees and crops. They used a simulation model to show that while the hedgerows competed severely with crops, competition was for light and not nutrients or water. In practice, for alley cropping to work trees need to be heavily pruned so that benefits of added soil fertility don't outweigh crop losses due to shading.

Other forestry-related research projects at CTAHR and UH Mānoa include:

- Ecology of koa decline and koa pathology. James Fownes (CTAHR), James Brewbaker (CTAHR), Curt Daehler (UH Botany), Rob Anderson (UH Botany) and Don Gardner (UH Botany).
- Genetic diversity of native *Acacia koa* populations. Candace Felling (UH Botany) and Cliff Morden (UH Botany).
- Cost-effective management of weedy species in native forests. Philip Motooka (CTAHR).
- Invasiveness of tropical ash in native Hawaiian forests. J. B. Friday (CTAHR), Adrian Ares (CTAHR), Sean Gleason (CTAHR), and Paul Scowcroft (USDA Forest Service).
- Economic impact of the forest industry in Hawaii. John Yanagida (CTAHR), Richard Bowen (CTAHR), and J. B. Friday (CTAHR).
- Protection of Hawaiian woods from termite attack. Ken Grace (CTAHR).
- Biological control of weeds in Hawaiian forests. Eduardo Trujillo (CTAHR).
- Ecology of mangroves in Kosrae, Micronesia. Sean Gleason (CTAHR) and Katherine Ewel (USDA Forest Service Institute of Pacific Islands Forestry).

- Cultivation techniques and disease prevention for awa and noni. Scot Nelson (CTAHR).

For more information on research in forestry and forest ecology, see the following websites:

- CTAHR forestry research:
<http://www2.ctahr.hawaii.edu/forestry/Data/researchProjects.html>
- UH Mānoa Botany department:
<http://www.botany.hawaii.edu/>

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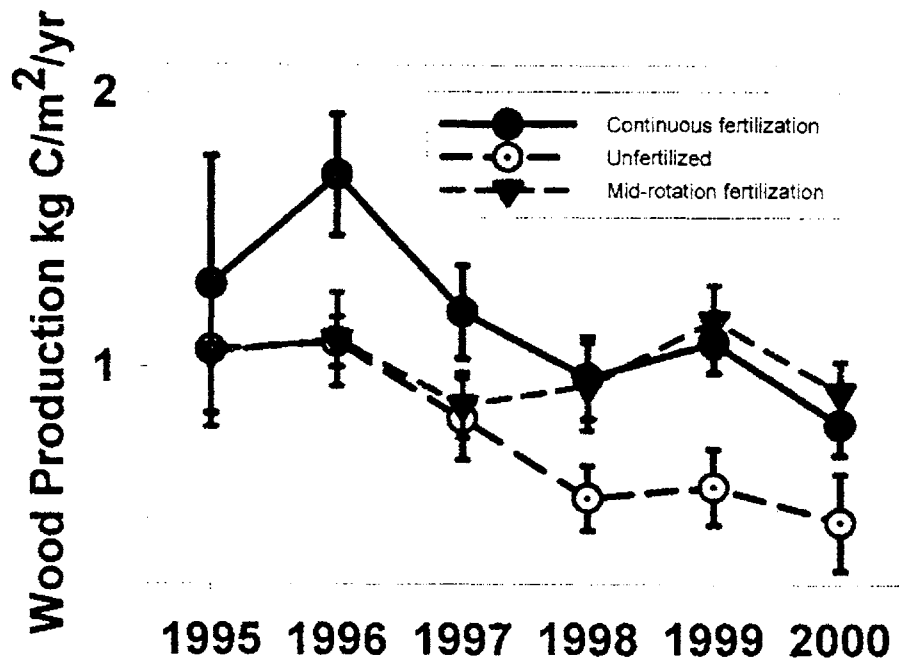


Figure 1. Eucalyptus wood production in Pepe'eko, HI, increased with fertilization late in the rotation.

Research Update: Hawai'i Agriculture Research Center

Nick Dudley

The Hawai'i Agriculture Research Center focus is project-oriented forestry research with the objective of increasing productivity and quality and enhancing sustainability for our forestry enterprise partners. During this past year, the three areas of concentration were tree improvement, timber stand improvement, and development of environmentally friendly silvicultural methods.

The tree improvement efforts ranged from training workshops with Hawai'i Forest Industry Association members to installing genetic tests. The focus of the testing is with *Acacia koa* and other high value hardwoods including *Dalbergia* species, *Senna siamea*, and *Tectona grandis*, and provenance testing with *Eucalyptus grandis*.

The genetic tests are designed to identify which species, provenances (seed sources from specific geographic locations), families (seed from a single mother tree), or clones are best adapted to a specific growing environments. Growth measurements were continued for previously installed provenance and clonal trials across a range of diverse sites in Hawai'i. Early results indicate that growth performance is highly depend upon test site. This year a 100-entry *Eucalyptus grandis* family test was installed at high elevation on Parker Ranch land. In addition, *Acacia koa* tests were installed in cooperation with Maui Pineapple Company at the Honolulu planta-

tion, Kamehameha Schools at the Kawaihoa Plantation, and with the University of Hawai'i at the Hāmākua Research Station.

The timber stand improvement work focus is to develop silvicultural prescriptions for koa management. From this work, we hope to better understand methods to promote koa stand vigor and growth. In addition, there is the opportunity to learn more about the response of native birds and other ecosystem components to forestry practices. Much time this year has been spent on the environmental permitting process and collecting base line growth and stand structure data. This project is sponsored by Hawai'i Forestry and Communities Initiative with University of Hawai'i, USDA Forest Service, and Kamehameha Schools cooperating.

Finally, work is proceeding with development of environmentally-friendly silvicultural methods. Fields are most susceptible to erosion during the establishment phase of forestry operations. Polluted run-off can lead to contamination of surface waters by sediment, nutrients, and herbicides. At present, there are no recommended ground covers for use in the establishment of forestry operations in Hawai'i. This project seeks to identify cover crops useful for erosion control in tree farms. The demonstration consists of cool season small grains, legumes, and several native grasses. The State of Hawai'i Department of Health is sponsoring the ground cover trials.

Symposium Synopsis and Discussion

J. B. Friday, UH Mānoa CTAHR

Forestry is an applied science. Most of forestry, and most of what we've heard here in the past two days, has to do with applying the sciences of ecology and biology to produce the results we want. Science tells us what will happen; the application of economics, planning, and management tells us how to get what we want.

We heard several presentations on the biology of tree growth: from John Edson on nursery stock, from Bart Potter on the silvics of many different forest trees, and from J. B. Friday on the growth and development of forest stands. We heard presentations on how trees respond to the many aspects of their environment. Bob Joy described how trees function in windbreaks, Randy Senock outlined how soil fertility affects tree growth, Tommy Crabbe and Mike Robinson outlined how the management of soil during site preparation and outplanting affects tree growth, and Bill Covern used several examples from his own tree farm in describing how trees respond to micro-climates and micro-site differences. The tree's environment invariably includes pests, diseases, and weeds, and sometimes fire. Wayne Nishijima and Earl Campbell gave some examples of what forest pests exist in Hawai'i and how to manage them; Joe DeFrank described how to manage the tree's environment to control weeds, and Bryon Stevens outlined how to manage forests to avoid wildfires.

Several presenters explained how trees in our tree farms affect Hawai'i's overall environment. Lionel Kutner forests can sequester carbon and help mitigate global warming. Duane Nelson warned us that some useful forestry trees can also escape and take over native forests.

Three themes emerged in management: Planning, Education, and Vision. Rick Hamilton, visiting us from NC State, showed us with examples from his home state how much money proper economic and management

planning can save us and indeed how a good management plan can make the difference between a successful tree farm and a failure. Ron Peyton told us about many cost-share programs that are available to tree farmers. J.B. Friday ran through a sample financial analysis for a tree farm in Hawai'i. Keith Argow of the National Woodlands Owners' Association held out the possibility that a good plan could lead to "green" environmental certification for our tree farms.

Updates on current forestry research were presented by Nick Dudley of the Hawai'i Agriculture Research Center, Randy Senock of the University of Hawai'i at Hilo, and J. B. Friday of the University of Hawai'i at Mānoa. Education, however, doesn't end with the experiments, but with communicating the results of the experiments to people who need them. In that sense, this conference is the culmination of the educational process.

The Hawai'i Forest Industry Association, for more than ten years, has had a vision for forestry in Hawai'i. This conference was all about what people are doing now, rather than what ought to be done. Forestry is taking off, but there's still a long way to go. Peter Simmons envisioned 30,000 acres being actively managed for koa. Don Reidel envisioned a bamboo industry for timber and edible shoots. Tensions and contradictions remain. While tree farmers like to grow rare and exotic trees and native Hawaiian species, most also expect to see an economic return from their lands. The intensive site preparation and pest treatments that agricultural producers in Hawai'i use maybe the best thing for the tree's health, but they may not be economic. The fastest-growing, hardiest trees may also be the worst weeds when they escape into native ecosystems. Local tree farmers will continue to grapple with these tensions and contradictions as new answers emerge. Tree farming in Hawai'i is here to stay.

Speaker Biographies and Contact Information

Keith Argow

Sustainable Forestry from a Landowner's Perspective and the Green Tag Program

Biographical summary:

Keith Argow is a forester and woodland owner with 2000 acres of actively managed timberlands in four states. . . a background that has prepared him to serve as president of the National Woodland Owners Association, as well as director of legislation for the nationwide Alliance of Forest & Woodland Owner Associations.

He has been actively involved in forestry issues, including the Coalition to Sustain American Forests, the American Forest Congress, and past Chair of the National Council on Private Forests. He serves as President of the National Forestry Association and directs their new Green Tag Forestry Certification program. He was elected a Fellow in the Society of American Foresters.

Raised in Oregon, he received undergraduate degrees from Colorado College (Economics—elected to Phi Beta Kappa) and the University of Michigan (Bachelors and Masters in Forestry). He holds a Ph.D. in Forestry and Political Science from N.C. State University.

Keith's varied career includes military service (Captain, U.S. Army Infantry), U.S. Forest Service (District Ranger, Research Forester and Administrator of the Mount Rogers National Recreation Area), Forestry Professor (N.C. State and Virginia Tech), and Executive Director of Trout Unlimited.

For the past twenty years, he has been the principal in American Resources, Inc., a nationwide Conservation Service Organization active in forest management, land acquisition, historic fire lookout restoration, and forestry advocacy.

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Bill Covern

Selecting Sites for Commercial Forest Operations

Biographical summary:

Bill is the president of Hawaiian Mahogany Co., Inc. and owner/operator of Hale Kua, a guest cottage business. He has served as vice president of the Kaua'i County Farm Bureau, chairman of the RC&D forestry committee, and chairman of the County Tax Board of Review. Bill majored in forestry at the University of Massachusetts. He has planted over 100 tropical timber species; he is presently planting 4000 acres on Kaua'i in commercial timber. His long-term goal is to establish a moderate-sized forest industry on Kaua'i producing not only lumber, but finished products as well.

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Tommy Crabb

Preparing Sites for Tree Farming

Biographical summary:

Tommy Crabb retired from C. Brewer & Co., Ltd. after holding numerous executive positions in the sugar industry. He spent his final fifteen years as Vice-President /Manager of BioEnergy Development Corp. With technical assistance from the USDA Forest Service, Tommy researched the feasibility of growing commercial short-rotation eucalyptus as a biomass energy crop as well as for alternate higher value use products such as paper pulp, medium density fiberboard and strand board. The research project covered 750 acres at nine sites along the Hilo coast and in Ka'u. The research resulted in recommendations of management practices relating to tree farm establishment, and maintenance as well as harvesting, marketing and economics. Tommy's work has put him in touch with producers in both the West Coast and Asia. He continues his involvement as a volunteer with various Federal agencies.

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Joseph DeFrank

Forest Weed Control

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M.S., Horticulture (Weed Science), Michigan State University, 12/15/79
Ph.D., Horticulture (Weed Science), Michigan State University, 10/10/83

Professional History:

Associate Professor, Dept. of Horticulture, University of Hawaii, 11/83-7/89
Assistant Professor, Dept. of Horticulture, University of Hawaii 7/89-6/95
Professor, Dept. of Tropical Plant and Soil Sciences 6/95- present

Current research projects:

Dr. DeFrank is developing technology to address the weed control needs in a variety of crops across the Hawaiian Islands. He is identifying safe and effective chemical tools for weed control in potted orchids, anthuriums and foliage plants for export. He has developed no-tillage cropping systems that make use of living mulches in crops such as eggplant, pineapple and native Hawaiian plants in an ecosystem restoration setting. In cooperation with the NRCS on Moloka'i, Dr. DeFrank is also working on weed free seed production of native Hawaiian plants for use in vegetating Kaho'olawe.

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Nick Dudley

Research Update, Hawai'i Agriculture Research Center

Biography:

Nick Dudley is the Forester and Forestry Team leader at Hawai'i Agriculture Research Center. His degrees are from Michigan State University (BS) and the University of Hawai'i (MS). The primary focus of his work has been developing tree-based cropping systems and reforestation strategies for former agricultural and ranch lands in Hawai'i.

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John Edson

Selecting Seed and Seedlings for Working Forests

Biographical summary:

John Edson has owned and operated a private forest nursery and consulting business on Kaua'i for the past four years. He is a practicing silviculturist specializing in reforestation. Prior professional forestry experience was gained in tropical Australia, Central American, South Pacific Islands, and the Pacific Northwest.

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Bill Eger

Property Tax Comparison by Island

Biographical summary:

Bill Eger, 66, has been active in politics and government all his adult life. He was a reporter and editor with newspapers and the United Press International on the mainland. He has also served as campaign manager and staff member to city, county, and state government officials. Bill served four years on the Hawai'i County Real Property Tax Board of Review and he recently completed a brief study of tax differences for the State of Hawai'i. A former member of the board and treasurer of HFIA, he is a partner in Cannon and Eger Public Relations on the Big Island, an internet webmaster, and a programmer and computer consultant.

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Peter Follett

Tree Insects

Biographical summary:

Dr. Peter Follett is a research entomologist with the U.S. Pacific Basin Agricultural Research Center, USDA, ARS, in Hilo, Hawai'i. His research interests are in invasive species ecology, integrated pest management of tropical fruits, and postharvest quarantine treatment technology.

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J. B. Friday

Economic Analysis of Tree Farms
Stand Management: Thinning and Pruning for Best Production
Research Update, University of Hawai'i at Mānoa

Biographical summary:

J. B. Friday is the extension specialist in forestry for the University of Hawai'i. He works with landowners, tree farmers, and other professional foresters throughout the state on management of both native forests and tree farms. His particular interests are in agroforestry, silviculture of koa, and management of high value plantation timber species.

Prior to coming to Hawai'i, Dr. Friday worked in agroforestry extension in the Philippines with the US Peace Corps. Dr. Friday is originally from the northeast, where he earned a bachelors degree in biology at Dartmouth in 1982 and a masters in forestry at the Yale School of Forestry and Environmental Studies in 1985. He did his doctoral research on agroforestry on Kaua'i on competition between hedgerows and crops for light and nutrients and graduated from UH Mānoa in 1998.

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Rick Hamilton

Information Vital to Cost Effective Forestry

Biographical summary:

Rick Hamilton is the Extension Forestry Specialist and Department Extension Leader at North Carolina State University. His career has been devoted to educational programming for non-industrial private forest landowners. He is the author of 70 extension publications and fact sheets covering forest management, timber taxation, forest economics, forest herbicides, water quality and forest stewardship. Rick is past chair of the association of Natural Resources Extension Professionals, current Appalachian Society of American Foresters Chair and Chair of the Southern Extension Forest Resources Specialist Association, as well as a member of numerous North Carolina committees and policy partnerships.

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Max Hensley

Panel on Hardwood Forestry
Koa Silviculture: A Realistic Model

Biographical summary:

Max Hensley has been pursuing a Hawaiian investment in the cultivation of fine cabinet hardwoods since 1998, with an emphasis on *Acacia koa*. While Mr. Hensley is not a professional forester, being employed as the chief intellectual property attorney for a San Francisco-area biotech company, his experience in black walnut improvement and silviculture on his family farm in Missouri provoked his interest in koa and the potential of this species for similar advances on Hawaii. He is an amateur woodworker who has come to appreciate the

beauty of Hawaii's woods and believes it is important to make economically viable investments now to provide for future generations.

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Robert Joy

Protecting Trees with Windbreaks

Biographical summary:

Robert Joy is a Plant Materials Specialist with the Natural Resources Conservation Service (NRCS). He provides technical guidance in the use of plant materials and is responsible for carrying out a systematic plant selection, evaluation and improvement program of plants used in soil and water conservation in Hawai'i and the Pacific Basin. He has been with the NRCS since 1968. He received his B.S. in Horticulture in 1961 and M.S. in Agronomy in 1970 from the University of Arizona. He has been author or co-author of 15 scientific publications in cooperation with researchers at the University of Hawai'i and University of Arizona.

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Lionel Kutner

Revenue from Carbon Sequestration in Forests

Biographical summary:

Lionel Kutner is co founder and president of the TREES FOR LIFE Foundation, which organized in 1997 to bring voluntary funding to global reforestation. TFL partners with PAC RIM Association of RC&D's on the topic of carbon sequestration and marketing carbon credits for forestry. Under contract to Hawaii Forestry and Communities Initiative, he organized the 1999 conference, "CARBON SEQUESTRATION in HAWAII'S FOR-

ESTS - Linking Economic Development with Environmental Protection" at Hawaii State Capitol

Prior to forming TFL, Mr. Kutner had a consulting career in market research and advertising in Chicago, in London, and as owner of Ad Studio Kona (which served the Big Island for 1985-1996). A native of Dublin, Ireland and graduate of Trinity College, Dublin, he holds an M.A. in experimental psychology. He has lived in Kona, Hawai'i since 1980.

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Duane Nelson

Avoiding Tree Species Which May Become Invasive Weeds

Biography:

Duane has been with the Forest Service for 21 years, most recently serving as the Forest Health Coordinator with the Institute of Pacific Island Forestry in Hilo, Hawai'i. Duane chairs the Big Island Invasive Species Committee (BIISC), and the Coordinating Group for Alien Pest Species (CGAPS) in Hawaii. He is a Certified Silviculturist in Forest Service Pacific Southwest Region. He has served as a land management planner in Region 5, and the Eldorado National Forest, and has worked in timber sale preparation, sale administration, reforestation and the forest genetics program in California. He holds a B.S. in Forest Management from the University of Missouri and has done post-graduate work in forest management and silviculture at Washington State University and the University of California, Berkeley.

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Ron Peyton

Government Incentive Programs for Forestry

Biographical summary:

Ron Peyton is the District Conservationist on Kaua'i for the U. S. Department of Agriculture, Natural Resources Conservation Service. Ron has been assigned to the local Lihu'e Field Office for the past six years. Prior to that, he served in various forestry and conservation assignments in Idaho and Washington State and has been with NRCS (formerly the Soil Conservation Service) for twenty-four years. Ron graduated from Washington State University in 1966 with a B. S. degree in Forest Management. Ron worked several summers with the U. S. Forest Service in the Pacific Northwest and spent over eight years in the U. S. Army. Ron provides conservation planning assistance to the two local Soil and Water Conservation Districts (the Hanalei American Heritage River Program and the Garden Island RC&D Forestry Committee). He is a member of the Soil and Water Conservation Society, volunteers with the National Tropical Botanical Garden and the Koke'e Natural History Museum, and served one term as a Hawai'i Forest Industry Association board member

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Bart Potter

Hedging Your Bets: Selecting Tree Species to Deliver a Continuum of Value

Biographical summary:

Bart Potter owns and operates a small sawmill on O'ahu and specializes in producing tonewood from Hawaiian-grown trees for the guitar industry. Since he began his business in 1974, Bart has milled and worked with many native and introduced woods grown in the state. He looks to the many trees already established here as a valuable record and a source of information and inspiration when choosing which species to plant. He is a founding member of HFIA and currently serves on the Board of Directors.

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Donald Riedel

Bamboo Guild
Garden Island RC&D Forestry Committee

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Sally Rice

President, Hawai'i Forest Industry Association

Biographical summary:

Sally Rice has been an active member of the Hawai'i agri-business community for 43 years. She is a graduate of the College of Agriculture, Cornell University, with a B.S. degree in Animal Science. She presently has management responsibility for the Kona Division of Agro Resources, Inc. and development of commercial tree farms, coffee orchards, macadamia orchards, tropical fruit orchards, a native forest reforestation project, and cattle ranches. Sally is the President of HFIA, director of the Hawaii Tropical Fruit Growers, founding member of TREE (Tropical Reforestation Ecosystem Education) Center, and member of the Kona Farm Bureau and The Nature Conservancy of Hawai'i.

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Mike Robinson

Planting a Commercial Tree Farm

Biographical summary:

Since June 1997, Mike Robinson has been working with the State as the Coordinator of the Hawai'i Forestry and Communities Initiative (Na Hoa Mahi'ai). This coalition of six State agencies and three Federal agencies, working in partnership with businesses, communities, and other agencies, is dedicated to diversifying Hawaii's economy through forestry.

Mike also owns and operates RESOURCE MANAGEMENT, a natural resource planning and project management firm in Hilo since 1988. Prior to that, he managed public forests in West Africa, Micronesia, and throughout the western United States.

In 1999, he began establishing a tree plantation on land he co-owns in Hamakua on the Big Island. Mike is a past Board Member of the Hawai'i Forest Industry Association, and served three years as their Executive Director. He has chaired several statewide forestry committees, including the Economic Development working group for Senator Akaka's Forest Recovery Act Implementation Plan. Mike is also a past member of the State's Forest Stewardship Committee. He is a certified professional forester with the Society of American Foresters, and a twenty-year member of the International Society of Tropical Foresters.

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Randy Senock

Fertilizing Trees for Optimum Production
UH Hilo Forestry Update

Biographical summary:

Randy is an Assistant Professor in the College of Agriculture, Forestry and Natural Resource Management at UH Hilo and is coordinating the development of the UHH forestry program. He has been involved in forestry education and research in Hawai'i since 1994. He recently coordinated a mechanized harvest training pro-

gram for local workforce development. Randy believes that a UH forestry program can contribute to the development of a forest industry that is sustainable from both a natural resource management and local community development aspect. He also believes that HFIA can continue to play a key role by bringing together all segments of the community that depend upon forest products for their livelihood.

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Peter Simmons

Panel on Hardwood Forestry

Biographical summary:

A founding member and past president of HFIA, Peter currently serves as HFIA's Treasurer and heads the Industrial Forest Committee. He manages Kamehameha Schools' Forestry and Natural Resource Department, and was formerly the manager of McCandless Ranch, in charge of their land management and timber operation. Peter has served on a number of forestry commissions and task forces over the years, including chairing the RC&D Forestry Committee from 1988 through 1992. He is also a board member of the Tropical Reforestation and Ecosystems Education Center in Kona.

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Bryon Stevens

Protecting Tree Farms from Fire

Biographical summary:

Byron Stevens is the protection forester for the State Division of Forestry and Wildlife, Kaua'i branch. Besides dealing with concerns such as invasive alien species, he also has the unenviable task of protecting Kauai's hurricane damaged and drought stricken Forest Reserves from fire.

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